DEFENDER FOR DAKAR

How JLR's Dakar assault could transform Rally-Raid

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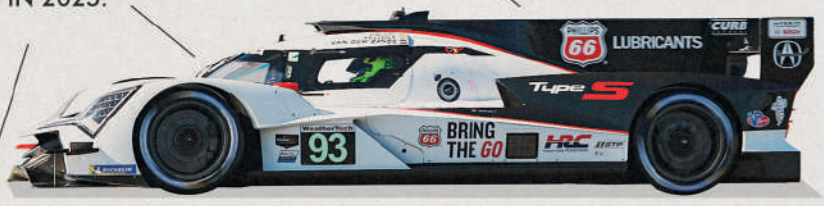

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ONE THING MONEY CAN'T BUY...

JANUARY was a slow month for Artificial Intelligence. Instead of potentially exterminating the whole of mankind, as has so often been predicted, it instead contented itself with merely demolishing confidence on Wall Street and the pride of the world's biggest superpower.

It was the emergence of DeepSeek, the Chinese AI app, that set the world talking, as news of its lower-cost chips spooked the US economy. Chip-making giant Nvidia recorded the biggest one-day loss in US history, with market analysts estimating the combined losses in market value across US tech at well over $1trn (£802bn).

A quiet day at the office, then.

Why is this of note to Race Tech? Because AI is billed as the next Industrial Revolution and the rush for tech supremacy isn't confined just to Washington and Beijing. It's occupying the minds of sanctioning bodies, manufacturers and teams alike.

That much was evidenced by the subject of this month's cover feature: compute giant Arm's new partnership with Aston Martin Aramco Formula 1 Team. The latter has signed Adrian Newey and Andy Cowell, coveted gurus in the fields of aerodynamics, powertrains and much more beyond, to guide it through the 2026 F1 rules upheaval. It has also built the newest wind tunnel in Formula 1 and has a sparkling new tech campus to work from. Oh, and signed reigning world champion Honda as its engine partner.

However, there is one thing that money can't buy: time. And one disruptive technology, Artificial Intelligence, quickly earning a reputation for helping target teams' activities, saving them that precious commodity.

The NASDAQ might not be too chuffed with AI right now, but teams are loving it. A glance at our cover feature will reveal why.

Aston Martin Aramco F1 has a number of AI projects it is itching to get Arm started on. For its part, you can almost see the chip giant's AI eyes bulging wide in anticipation of the data-rich playground it is inheriting: over 300 sensors, 5,000 points of data, 3 TB of information to be gleaned every race!

Both parties are passionate about inspiring the next generation. Charlie Blackwall, the F1 squad's head of electronics, explains that he wants to see more people exposed to AI, learning how to harness it properly.

Elsewhere in the mag we look both at conventional engineering (M-Sport's Ford Raptor T1+), the new-norm (Jaguar's Gen3 Evo Formula E car) and one series torn uncomfortably between the two: the World Rally Championship. The roadmap for the WRC's future acknowledges the uncomfortable fact that nobody truly knows quite where the energy transition is taking us, nor how quickly we will arrive at our destination!

One thing looks beyond doubt – AI is going to play a role in that journey. We are certainly going to be better working with AI, than we are trying to pretend that none of this is happening.

Or at least that's what my AI chatbot is telling me... RT

Mark Skewis
EDITOR

THE 'GT3' OF THE DESERT?

JLR's Dakar assault could be the catalyst for a GT3-style revolution in Rally-Raid's stock category. By **Mark Skewis**

JLR's decision to enter Dakar and the FIA World Rally-Raid Championship (W2RC) from 2026 could help spark a Rally-Raid revolution.

The toughest event in motorsport has been the playground of the manufacturers since Peugeot embarked on a string of four victories back-to-back from 1987 to 1990: firstly with the 205T16, a Group B rallying refugee, and then the 405T16.

That trend reached its zenith in 2024 when Audi's RS Q e-tron, driven by Carlos Sainz and Lucas Cruz, became the first car with an alternative drivetrain to win the Dakar Rally. Such was the magnitude of the engineering challenge involved that Audi's engineers conceded the project was their own "moonshot". A hard act to follow, then.

But JLR's announcement that it will field two examples of its popular Defender brand in all rounds of the World Rally-Raid Championship next year – with an additional vehicle added to its line-up for Dakar – could provide a clue as to the off-road category's next 'gold rush'.

New regulations aimed at making the 'Stock' category significantly more competitive will be implemented by 2026, as the FIA and Dakar organisers respond to the growing popularity of high-performance 4x4s and SUVs. It's the increased performance these new regulations permit that has enticed JLR, persuading it that the Stock category could offer the perfect platform to authentically demonstrate Defender's extreme durability and capability.

Vision for the future

"We had a vision for the future of production-based vehicles in rally-raid so it has been incredibly positive to align with the ASO, FIA and other manufacturers and work collaboratively to create the new regulations for the 'Stock' category," said James Barclay, JLR Motorsport Managing Director. "We now have the right platform to authentically demonstrate Defender's capability in the biggest challenge in off-road motorsport."

Explaining the decision to enter Dakar in the Stock division, as opposed to the Ultimate class that features prototypes from the likes of Toyota, Dacia and Ford, Barclay said: "For us to come with Ultimate is not authentic, the Defender is the original off-road vehicle. It was the

JLR

JLR

ABOVE The OCTA has been chosen as the platform for the programme

first four-wheel drive off-roader in history, so for us to come into motorsport, it's not like we have to.

"It's only if we can do it the right way, and the right way is to demonstrate the capability of our incredible Defender as a production car, if we come with a spaceframe car that looks like a Defender, it's not authentic in our opinion.

"We wanted the challenge to be about bringing our real car to show what it is capable of, and to support this vision.

Modern reality

"ASO and the FIA had to look at the regulations and say, 'OK, we need to improve it'. The regulations were based on a very old concept of a production vehicle, and what we've done is work with the FIA and ASO to bring the regulations in line with the reality of what a modern production SUV is.

"When you look at off-road sport, we think there is a big opportunity, if you compare GT3 and GT4 in circuit racing. In 2000 when the category was created, there was very little GT racing, and if you look at it now, GT racing is prolific with GT3 and GT4, whereas in off-road racing, there is a big opportunity."

LEFT & BELOW JLR's commitment to the new Stock regulations has the potential to transform the rally-raid category, drawing comparisons with the explosion of interest in GT3 circuit racing

DPPI/WEC

It's telling that Defender's technical partner for the venture will be Prodrive. The British powerhouse brings four decades of engineering prowess, with a long history with endurance rallying, forged initially with Porsche and most recently with the Hunter and Dacia Sandrider assaults on the top class.

Prodrive's ethos fits perfectly too with the ambition to take the stock Rally-Raid category to the next level: both in terms of performance and popularity. David Richards' creation is one of the finest exponents of sports car racing's GT divisions. It recorded 151 podium finishes with its iconic Ferrari 550 GT1 and has won 11 GT titles for Aston Martin since setting up a race programme in 2004.

"Prodrive's experience will be invaluable to the programme," admitted Barclay and it seems that in terms of everyone's ambition to create another GT3-style success story, the stars have aligned.

Fastest Defender

Defender OCTA – the fastest and most capable Defender ever made – will form the basis of Defender's Dakar and FIA World Rally-Raid Championship competition challenger from 2026. At the core of the Defender OCTA – and retained for the competition vehicles – is its robust D7x (for extreme) body architecture. Based on the lightweight aluminium monocoque construction that forms the basis of every Defender, it is three times stronger than traditional 'body-on-frame' designs and provides impressive torsional rigidity.

This inherent robustness, coupled with the Defender OCTA's bespoke geometry and kinematic design, made it the obvious choice to underpin Defender's Dakar programme. The specially prepared competition vehicles will share Defender OCTA's body architecture, transmission and driveline layout – as per the Dakar and W2RC's regulations. Power will be provided by the OCTA's 4.4-litre twin-turbo V8 engine.

An exhaustive Defender competition test and development programme is already well underway. It will culminate in test events and a full team launch later this year ahead of Dakar and the FIA World Rally-Raid Championship in 2026.

While Defender will not compete in Dakar until 2026, it played a key role at the 2025 rally as the event's official vehicle partner in the first of a four-year agreement. A fleet of 20 Defenders supported the event, which began in Bisha, Saudi Arabia, and ended in Shubaytah, transporting race officials and VIP media. A further six highly specialised Defender recce vehicles will be used by Dakar Rally organisers to plan the routes for the 2026, 2027 and 2028 events.

Cowell takes charge as bold restructure testifies to Aston Martin's ambition

LEFT Cowell has evaluated all aspects of the way Aston Martin F1 operates

THE shrewd – and sometimes brutal – manner in which Aston Martin is being fashioned into a potential F1 title contender was revealed last month by a management reshuffle that promoted Andy Cowell to team principal.

Brutal, because the elevation of former Mercedes engine guru Cowell, who joined the team as group chief executive officer last October, effectively demotes Mike Krack. Krack, who had been Aston Martin team principal since 2022, will become chief trackside officer as part of changes that split the aerodynamics, engineering and performance departments into separate trackside and campus-based operations.

Shrewd, for team owner Lawrence Stroll has pulled off a coup few would have dreamed possible when the sport's 2026 rules makeover was first devised: luring superstars Adrian Newey and Cowell to a mid-grid team with anything but mid-grid aspirations.

Yes, their rewards were handsome – with Newey reputed to have been offered £30 million per season – but in both cases Stroll offered an incentive that glistened far beyond the bank balance.

The most successful engineer in F1 history, Newey was coveted by many but ultimately tempted by a shareholding – a new situation for him.

Responsibility

For Cowell, a man Mercedes team principal Toto Wolff once suggested could do any job he liked, the extra responsibility seems to have been the clincher.

He is best known as the architect of Mercedes' initial dominance in F1's hybrid era. The team's split turbocharger and compressor engine layout, subsequently adopted by rivals, was hailed as the 'double diffuser' innovation of the 2014 V6 engine ruleset. While far from the only trick that contributed to the squad's technical dominance, it was certainly a big factor in it becoming the most successful team in Formula 1 history from 2014-21.

As with Newey, the idea of being employed to do more of the same would never have been sufficient to tempt Cowell back to F1. Now, instead of being concerned solely with the efficiency of a new F1 powerplant, he has been tasked with improving the efficiency of Aston Martin's entire 900-strong workforce and its new state-of-the-art tech campus at Silverstone.

Never a fan of laborious meetings or reports, Cowell's mindset and talents would appear to make him ideal for the task ahead.

"I have spent the last three months understanding and assessing our performance, and I've been incredibly impressed by the dedication, commitment and hard work of this team," Cowell said of his new appointment.

Even before the reshuffle, the spark Cowell has brought to the team was evident. "Andy is very clear if he wants it like this or like that," was Krack's diplomatic assessment.

Cowell, for his part, had a clear view of the mission ahead.

"I don't like the phrase of rolling a dice, I'm more from the school of: 'you work hard and make your own luck'," he said of the team's approach to the opportunity afforded by the 2026 regulations upheaval.

"It is what somebody said about playing golf, the more I do, the luckier I get, so it is every single project I want us to get better at, it is not just targeting one point.

"It is a change for us, but I want to be amazingly creative on everything that we are working on and then really robotic with the way we do experiments and believe the result from the experiment.

"We will try and lose our emotional attachment to the idea when we look at the results and learn and get back around as fast as we can." RT

CONGRATULATIONS TO OUR TECHNICAL PARTNER INVICTA RACING AND GABRIEL BORTOLETO FOR WINNING THE FIA FORMULA 2 DRIVERS AND TEAM CHAMPIONSHIP!

Russ O'Blenes to lead Cadillac's F1 power unit arm

INDUSTRY veteran Russ O'Blenes has been named CEO of GM Performance Power Units LLC, a new venture that will build powertrains for the Cadillac Formula 1 team due to hit the grid in 2026.

With more than 30 years of motor racing engineering experience, O'Blenes is currently director of the GM Motorsports Propulsion and Performance team.

O'Blenes' career includes powertrain development for championship racing teams and award-winning production vehicles. He also led development of the GM Performance and Racing Center in Pontiac, Michigan, and the commercialization of the brand's eCrate initiative for performance car builders and EV enthusiasts.

"We're delighted to welcome Russ to this pivotal role," said Dan Towriss, CEO of TWG Motorsports. "His expertise and leadership will be instrumental as we lay the foundation for Cadillac's Formula 1 journey. Together with Team Principal Graeme Lowdon, they will lead the team in setting new standards of performance and innovation in the sport."

"Russ brings vast experience from many championship racing series, and has outstanding technical expertise, including spearheading our hybrid IMSA Cadillac and Corvette C8.R engines that are proven winners," said GM President Mark Reuss. "In F1, we're going to demonstrate GM's engineering and technology capabilities on a global stage, and Russ is the right choice to lead the Power Unit team that will make it happen."

O'Blenes is highly regarded within the industry for his drive but also his integrity. Reaction to his appointment has been understandably warm.

"Perfect choice by TWG Motorsports and GM to lead this endeavour," said Christopher Berube, a former Cadillac program engineering manager. "Great engineer, outstanding human and the hardest working individual I have ever met."

"I have worked with Russ for 30 years on the NASCAR engine program. They could not have picked a better person to head up this effort," agreed John Barilka 2nd, manager at Hendrick Motorsports.

Development and testing of the team's Formula 1 prototype engine technology is already underway.

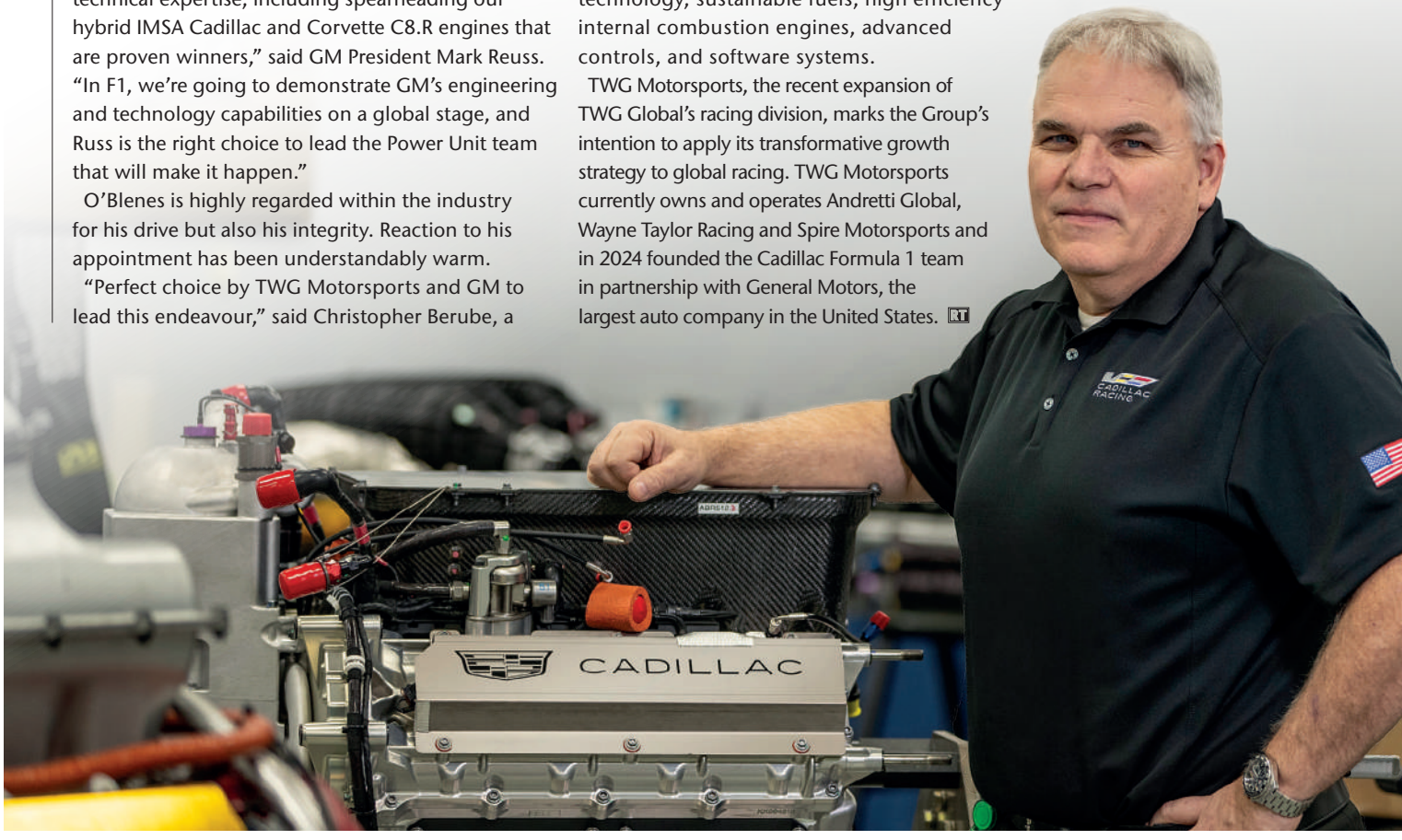
Plans are in place to open a dedicated facility for Performance Power Units LLC near GM's Charlotte Technical Center in 2026.

"I am truly excited to have the opportunity to build and lead the team that will bring an American-built F1 power unit to the grid," said O'Blenes. "GM PPU is currently ramping up its team and is hiring in all areas of the business."

The Cadillac Formula 1 Team will utilize Ferrari power units until the GM engines are approved for racing use.

GM's decision to engineer its own F1 power unit is intended to leverage and advance the auto maker's expertise in electrification, hybrid technology, sustainable fuels, high efficiency internal combustion engines, advanced controls, and software systems.

TWG Motorsports, the recent expansion of TWG Global's racing division, marks the Group's intention to apply its transformative growth strategy to global racing. TWG Motorsports currently owns and operates Andretti Global, Wayne Taylor Racing and Spire Motorsports and in 2024 founded the Cadillac Formula 1 team in partnership with General Motors, the largest auto company in the United States. RT



BELOW O'Blenes will help steer GM's F1 project

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Ford and McLaren to join endurance racing goldrush

McLAREN and Ford are both readying themselves for a return to top-flight sportscar racing.

Manufacturers are rushing to be part of a new golden era of endurance racing – with the World Endurance Championship's Hypercar ranks having converged with IMSA's new LMDh/GTP category – and it is believed that both McLaren and the Blue Oval will enter through the more cost-conscious LMDh route.

IMSA President John Doonan teased the anticipated further growth for IMSA's GTP class in the coming years during his pre-Rolex 24 press conference.

"For all of us who have had the opportunity to help put together the regulations, we are super-proud," he said. "As you know, we are not done yet. Genesis from the Hyundai family has announced they are coming and I've read the stories.

"It looks like the 'Papaya Army' (McLaren) plans to join us and maybe even the 'Blue Oval' (Ford). We are super-excited about what has happened and also what's to come."

McLaren is tipped to choose a Dallara chassis and has a ready-made partner team in the form of United Autosports, which already conducts WEC and IMSA campaigns with McLaren's GT3 Evo. The announcement of its intended entry would tie in nicely with the 30th anniversary of its Le Mans 24 Hours victory with the F1 GTR.

Ford is in advanced conversations with chassis constructors, along with investigating potential partner teams. It currently campaigns the Mustang GT3 model, developed with Multimatic, in IMSA's WeatherTech SportsCar Championship and with the privateer Proton Competition squad in the FIA World Endurance Championship. The Mustang GT3 scored its first victory last month, winning the GTD class in the Rolex 24 At Daytona.

Porsche, Acura, BMW, Cadillac and Lamborghini are already competing in IMSA's GTP division using the LMDh platform. Alpine has also campaigned an LMDh chassis in the WEC, while Hyundai's Genesis programme, due in 2026 in WEC and 2027 in GTP, is also being designed to LMDh standards.

Doonan and his team at IMSA are also believed to be trying to find a solution – and space on the grid – for Alpine to bring its A424 to IMSA in the future to coincide with the reported planned introduction of its road cars to the North American marketplace.

Ford's first global prototype campaign culminated in glory with the GT40, which won the 24 Hours of Le Mans four consecutive times from 1966-1969. The first of those victories marked the first time an American car manufacturer had won a major European race since 1921.

ABOVE Ford and McLaren will both join the LMDh ranks

Since then, Ford's C100 prototype, conceived and focused on European endurance racing, competed in the early '80s. In America, Bob Riley's front-engine Mustang GTP won on debut in 1981, while the Ford Probe GTP raced in the mid-'80s. More recently, its EcoBoost engines proved popular in the Daytona Prototype class.

The American manufacturer won the GTE class at Le Mans, with its Ford GT in 2016, 50 years after its first triumph there but an LMDh project would offer the tantalising prospect of fighting for outright honours once more at the French endurance classic. RT

PACETEQ appoints Single Seater Lead

DATA technology specialist PACETEQ has been joined by Kimi Raikkonen's former F1 engineer, Julien Simon-Chautemps, as Strategic Advisor & Single Seater Lead.

Simon-Chautemps will promote PACETEQ's tools and software services through high-profile engagements and via his engineering and strategy consultancy, JSC7 Engineering Ltd.

Alexander Bodo, CEO of PACETEQ, commented: "As an immensely talented and experienced motorsport engineering specialist, Julien understands the importance of the work we do and the difference that our products can make. When it comes to the competitive knife-edge of top-tier motorsport, understanding and processing critical data is integral to success."

Simon-Chautemps added: "Having worked in Formula 1 – at the frontier of motorsport technology – for 14 years, I have an immense appreciation for the work that PACETEQ does. Visibility of the right data at the right time, with analytical insights, makes the role of race engineering simultaneously far more consequential and straightforward. In this regard, PACETEQ is the industry leader, continually innovating and developing solutions with meaningful real-world benefits for motorsport teams." RT

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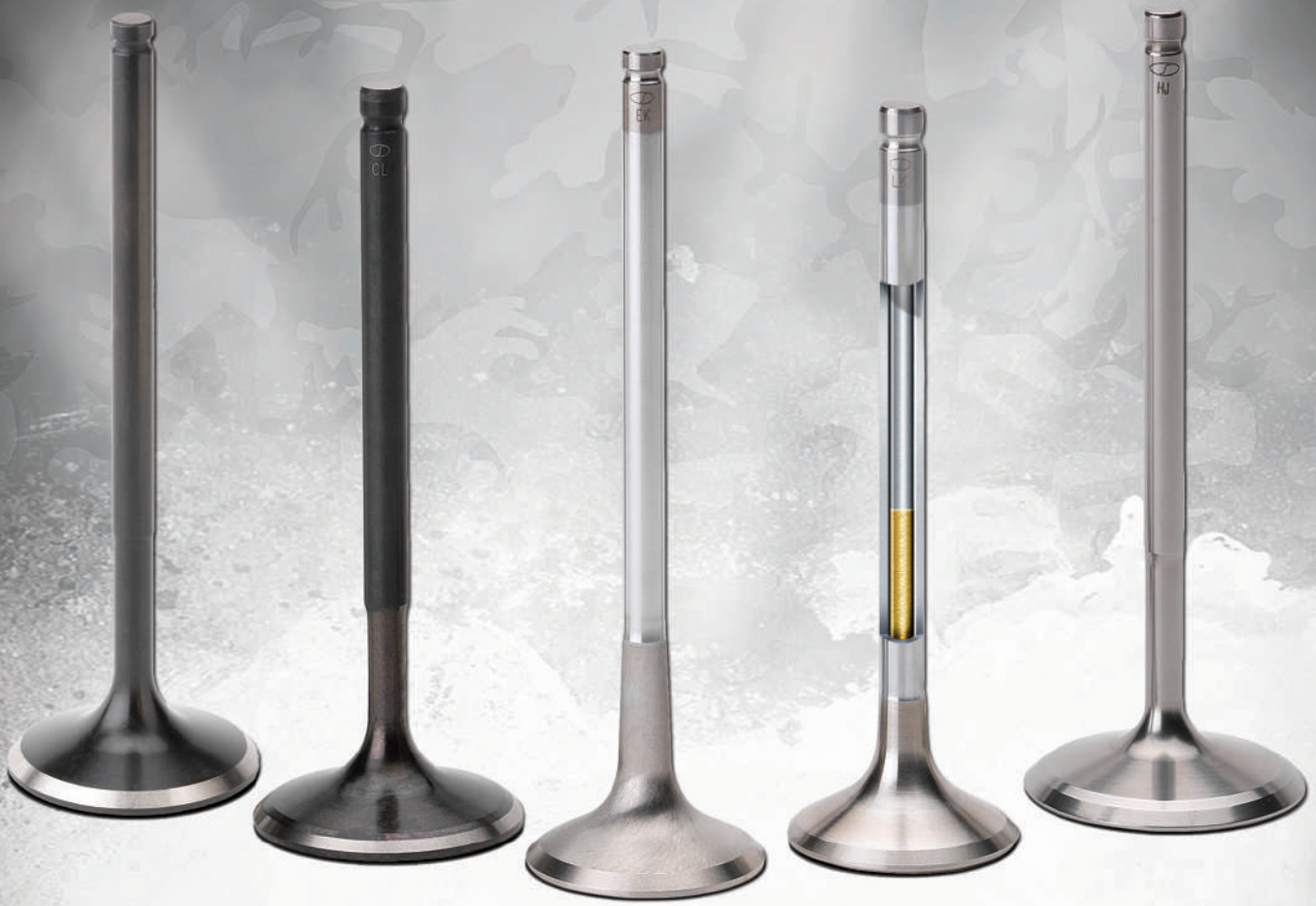

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F1 owner appoints new president

FORMULA 1 owner Liberty Media has appointed a new president and chief executive officer following Greg Maffei's departure last year.

Derek Chang, a veteran media, sports and entertainment executive, took on the role at the start of the month.

John Malone, chairman of Liberty Media, has been interim CEO since Maffei left. He said: "Derek's expertise in both operating and investment roles, extensive understanding of our industries and familiarity with Liberty make him the ideal leader for Liberty's next chapter."

Chang, who has been a director of Liberty since March 2021, is a former CEO of NBA China. He was named one of Cablefax Magazine's "Top 100 Executives in Cable" and one of the "50 Most Influential People in Sports Business" by SportsBusiness Journal.

He said: "Our current focus is clear: optimizing the portfolio structure with the split-off of Liberty Live and supporting the growth of our attractive operating assets, including F1 and MotoGP post-acquisition, to continue their momentum and invest for the future.

"Looking further, Liberty has always been long-term minded in its investment mandate yet nimble to move quickly on new opportunities. Both of these things will remain true in our strategy going forward."

Liberty took control of MotoGP in April last year, although the deal has yet to be approved by the European Commission.

F1 president and CEO Stefano Domenicali will report into a three-man Liberty executive board committee comprising Chang and fellow board members Chase Carey and Dob Bennett.

Carey, who was replaced by Domenicali as boss of F1 when the American left Liberty at the end of 2020, returned to the Liberty board in December. RT

TAG Heuer rolls back the clock

TAG Heuer is to replace Rolex as Formula 1's official timekeeper.

The development is part of a wider 10-year deal struck between Formula 1 and luxury brands group LVMH (Moët Hennessy Louis Vuitton).

TAG Heuer has a rich history in F1, spanning over seven decades. It was the first luxury brand to have its logo appear on a Formula 1 car in 1969, the first to sponsor a team in 1971 and, with 230 wins and 14 World Drivers' Championships to its name through its associations with teams, it is one of the most successful brands in history to be associated with the sport.

The brand's relationship with current teams began in 1971, when Ferrari needed a timing system for its Fiorano test track. The relationship ran until 1979, before Heuer continued with a partnership with McLaren in 1985, which would go on to be one of the longest in Formula 1 history, during which time Ayrton Senna, Mika Häkkinen, and Lewis Hamilton all raced for the team. The relationship came to an end after 30 years of collaboration and a year later, in 2016, TAG Heuer partnered with Red Bull. That relationship will continue alongside its role as the Official Timekeeper of Formula 1.

ABOVE TAG Heuer returns to its role as official F1 timekeeper

TAG Heuer is replacing Rolex, which has been F1's timekeeper since 2013.

Antoine Pin, CEO of TAG Heuer, said: "In a sport defined by mental resilience, physical strength, strategy, innovation and performance it is only natural for TAG Heuer to be at the very heart of Formula 1 as Official Timekeeper. With decades of history in F1 connecting us to the most successful drivers and teams of all-time, we are honoured and privileged to be the name connected to the very thing that defines the winner: time." RT

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ABOVE McLaren Racing has taken full control of its IndyCar team

McLaren completes acquisition of IndyCar squad

McLAREN Racing has taken over sole ownership of the Arrow McLaren IndyCar Team, following the final phase of its buyout from Sam Schmidt and Ric Peterson, deepening its commitment to motorsport in North America.

McLaren bought a 75% stake in the NTT IndyCar Series team in 2021, which had evolved from Schmidt Peterson Motorsports to Arrow McLaren SP and most recently to Arrow McLaren IndyCar Team in 2023. Schmidt and Peterson retained minority ownership from 2021-24.

"This is an exciting step for McLaren Racing as we grow and strengthen our presence in North America, which is a very important market for our team and our fans," McLaren Racing CEO Zak Brown said. "Sam Schmidt and Ric Peterson have been great partners and co-owners, and I want to thank them as we continue to build what they started many years ago, and that is a championship-calibre NTT IndyCar Series team."

Pato O'Ward, Nolan Siegel and Christian Lundgaard will form Arrow McLaren's three-driver lineup in the 2025 NTT IndyCar Series season.

"Stepping away from my ownership role with Arrow McLaren is bittersweet," Schmidt said. "This team has been my life's work, growing from a dream into a competitor at the highest level. I'm endlessly grateful to the drivers, team members, partners and fans who made it all possible and to McLaren for elevating the team's potential. While I'm stepping back from ownership, my heart will always be with this team, and I'll be cheering for its continued success every step of the way."

Peterson said: "Since I joined Sam as co-owner in 2013, it's been rewarding to see this team evolve. We welcomed Arrow as title partner in 2019, we joined forces with McLaren in 2021, we became a three-car NTT IndyCar Series team in 2023, and we celebrated many poles, podiums and wins in Indy Lights and IndyCar throughout those years. This team has a strong foundation for success, and Sam and I are proud of where we leave it."

The 2025 NTT IndyCar Series season starts Sunday, March 2 with the Firestone Grand Prix of St. Petersburg.

Formula E to reduce air freight emissions by at least 25%

FORMULA E has revealed that it will save at least 25% on freight-related CO2 emissions in its current season.

It has successfully worked with DHL and other key ecosystem partners to optimise championship freight and will be able to transport all essential equipment to races outside Europe in two cargo planes compared to previously three.

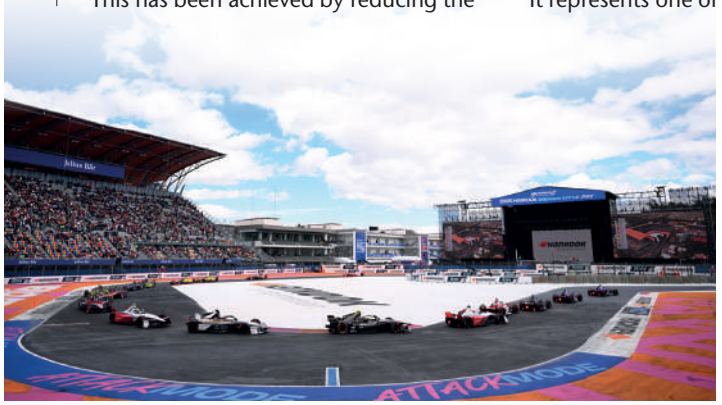
This has been achieved by reducing the volume of freight by more than 80 tons and opting to utilise in-market assets and multiple sets of assets it can transport more environmentally friendly via sea freight. This complex and ambitious initiative will save approximately 5,500 tons of carbon emissions across the 16-race calendar: the weight of more than two full Olympic-sized swimming pools.

It represents one of the most impactful steps in reducing the championship's emissions since it was formed back in 2014 and significantly contributes to its Science Based Targets initiative of reducing the series' carbon footprint by 45% by 2030, compared to Season 5's output.

Formula E's internal tech and logistics team worked directly with key partners to forensically audit, reduce and repack the amount of freight transported via aircraft, including finding ways to procure or store lots of their equipment and assets within race markets.

Julia Palle, Vice President Sustainability, Formula E, said: "We're proud to take our sustainability credentials and commitment to reducing our overall emissions to the next level.

"As a championship committed to sustainable racing, innovation and reducing our overall footprint on the planet, this represents not only a giant step forward in our mission, but lives up to our DNA of pursuing pioneering technology and solutions to accelerate more sustainable lifestyles and ultimately human progress."



LEFT The championship's longer journeys save up to 80% in carbon emissions from the use of renewable biofuel

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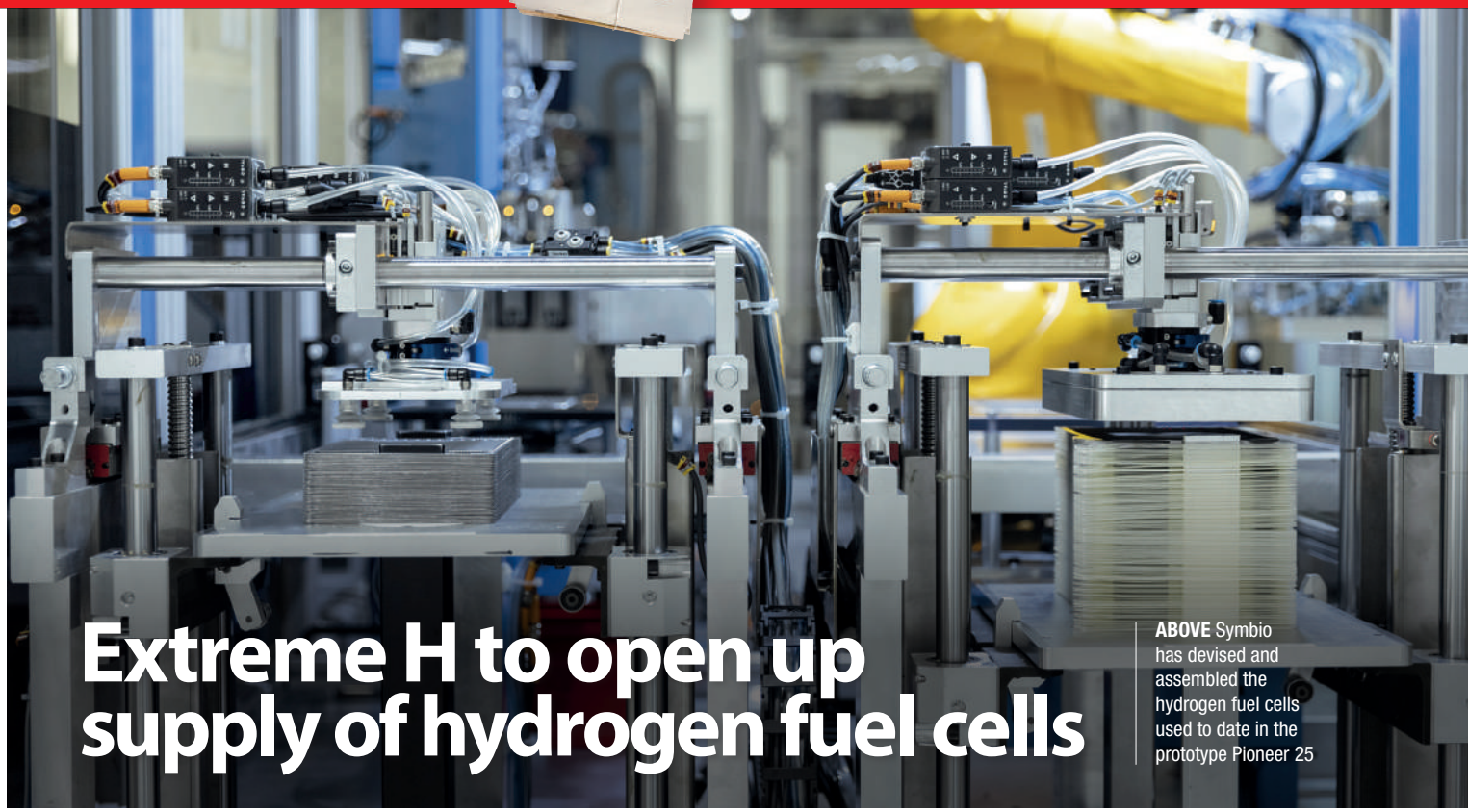

Extreme H to open up supply of hydrogen fuel cells

ABOVE Symbio has devised and assembled the hydrogen fuel cells used to date in the prototype Pioneer 25

EXTREME H is to open up the supply of hydrogen fuel cells to encourage manufacturer interest.

The move represents a notable shift in ethos for the series, which is due to become the first hydrogen-powered FIA World Championship.

Like its predecessor, Extreme E, Extreme H was originally slated to be a strictly single-make series in every aspect (aside from allowing small bodywork changes) in order to control costs. The prototype has been powered by Symbio's 75 kW fuel cell, but now OEMs will be allowed to integrate their own hydrogen fuel cells into the upcoming series' car, the Pioneer 25.

"The logic behind that is you've got road-to-race-to-road – you can take one of your existing off-the-shelf fuel cells that's not a race-specific development item and you can showcase it using Extreme H," explained Extreme H technical director Mark Grain.

"We are working with the FIA on a framework for regulations. We're very conscious that this is not a means to introduce runaway costs, it really is taking a standard item that you've got in your inventory and allowing you to race it, therefore demonstrating and promoting your technology via Extreme H."

Symbio Motorsport's 75 kW Stack Pack hydrogen fuel cell was likewise an 'off-the-shelf' product that was adapted to run in the Pioneer 25. Indeed, from the start of the project the French company has been adamant that the technology must be relevant to other industries.

Symbio's HFCs will supply the entire field initially. "They are our official partner and they have the capability, and the flexibility, to supply three cars, four cars or the whole field," said Grain. "We are both comfortable with that."

Grain has revealed that he has been in "strong conversations" with several potential manufacturers.

A number of OEMs became interested when hydrogen first featured on motorsport's radar with the ACO/FIA MissionH24 initiative to bring the technology to the Le Mans 24 Hours. One of the car-makers tempted was Hyundai, though its interest cooled when the FIA began to champion liquid hydrogen, rather than the fuel cell route which the initial prototypes for Le Mans had adopted.

Opening up the fuel cell supply inevitably raises the question of escalating costs. Grain believes the decision to only allow components that are already in production will enable them to still be controlled.

"We are hugely conscious of containing costs and that is why you'll be using your inventory so you should have these items available, then you'll do an installation into an existing car that the money's been spent on, shall we say," he said. "Inevitably that comes with some redesign and engineering work, of course, but we're not talking millions and millions of dollars by any means. It's actually quite achievable at a very cheap price."

Ways are also being examined to ensure that one manufacturer doesn't come in and blow away all the opposition.

"We don't want somebody to enter and run away with the championship," he said. "The rules mandate a hydrogen fuel cell can deliver a maximum of 75 kW into the battery. So you can have the world's most performant hydrogen fuel cell but that output is still limited to 75 kW and we can monitor that. Things won't run out of control.

"What that leaves us with is a great platform for OEMs to showcase their products in an extreme environment on a spectacular car and to say, 'Look at what our fuel cell can do. If you want to buy one of our cars, this is what it's capable of.'"

The forthcoming FIA Extreme H World Cup passed a major milestone last month when Spark Racing Technology completed production of its fleet of 10 Pioneer 25 race cars.

The vehicles feature a dual-motor, all-wheel-drive system, delivering up to 400 kW (550 hp) of power. Symbio has provided a 75-kW hydrogen fuel cell for the prototype, supplying power to the battery pack that is produced and supported trackside by Fortescue Zero. RT

Formula E plays fast-charging gambit in Jeddah

FAST-charging technology will be showcased in Formula E for the first time this month when 'Pit Boost' is introduced in one of the races at Jeddah's double-header in Saudi Arabia.

The technology has been developed for the series by Fortescue Zero (formerly WAE). Pit Boost provides a 10% energy increase (3.85 kWh) to race cars through a 30-second, 600 kW rapid recharge in the pit lane. This mandatory sporting feature – deploying significantly more power than current consumer superchargers – will add another strategic element during selected races, with the potential to dramatically alter teams' tactics.

Alberto Longo, Co-Founder and Chief Championship Officer, Formula E, said: "After an extensive testing and simulation process, we're pleased to finally present this game-changing technology to the world. It marks one of the most ambitious and impactful additions not just to our series, but modern-day motorsport.

"Pit Boost will challenge teams and drivers alike to make high-stakes decisions under intense pressure. As a series born to enhance the technology transfer from the racetrack to the road, it marks a step change for consumer vehicles and the future potential of EV performance."

Marek Nawarecki, Senior Circuit Sport Director, FIA, said: "Pit Boost underscores the FIA's steadfast commitment to developing evermore advanced race-to-road technologies – an approach that is perfectly exemplified by the ABB FIA Formula E World Championship."

By addressing one of the key challenges in EV adoption – charging speed and time – it is hoped Pit Boost will further showcase Formula E's intent to position itself as a 'race-to-road' technology platform.

Fortescue Zero was recently awarded A$10 million in funding from The Australian Renewable Energy Agency (ARENA) to develop a six megawatt (MW) fast charger test unit to support the company's innovative fast charger technology. The Project involves building, testing and validating multiple test unit chargers with the aim to deploy the first production 6MW charger by the end of 2025.

The 6MW fast charger will be compatible with a wide range of battery electric heavy mining equipment.

Formula E's Pit Boost concept was tested for the first time during a trial race at pre-season testing in Spain, with the data from that simulation outing analysed by the championship and governing body.

Strict protocols will govern the implementation of the new technology. Pit Boost will remain independent of existing Attack Mode rules, providing teams with two strategic elements to manage alongside one another. Only one of a team's cars will be permitted to carry out Pit Boost at a time (i.e. not simultaneously).

The FIA will determine the window to take Pit Boost (depending on a certain 'Status of Charge' value), which will be shared with teams 21 days before each race.

Toyota reveals mid-engined Yaris

TOYOTA revealed a new Super Taikyu Series vehicle, the Toyota GR Yaris M Concept, at Tokyo Auto Salon 2025.

Designed to further explore the potential of the GR Yaris, the car will feature an engine still under-development, a 2.0-litre, inline 4-cylinder, turbocharged unit. What really set tongues wagging is that the engine is mid-mounted, rather than at the front of the car.

It will run in the Super Taikyu's experimental class, where the manufacturer currently competes with a ROOKIE Racing-entered Corolla using a revolutionary liquid hydrogen ICE.

From 2025, TGR and ROOKIE Racing will compete in the Nürburgring Langstrecken Serie (NLS) and the Super Taikyu Series as a united squad: TOYOTA GAZOO ROOKIE Racing. The new team plans to mark Toyota's return to the Nürburgring 24 Hours endurance race after a six-year hiatus, entering with the evolved GR Yaris, which made its world debut at Tokyo Auto Salon 2024. The car is equipped with the newly-developed GAZOO Racing Direct Automatic Transmission.

BELOW The new engine will be mid-mounted

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Vice President and Chief of Staff, IndyCar

"Each year, the World Motorsport Symposium brings together a distinguished group of racing experts, each of which is an impactful leader in their field. Their knowledge, insight and transparency on the critical challenges and vision of motorsport make this event essential for industry professionals."

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"The Automotive World is, with each passing year, more and more difficult to predict. The target is well known: Zero CO2; but the way to achieve it on a large scale is dramatically challenging. In such a period, the World Motorsport Symposium, being so open-minded, is very valuable to share and challenge ideas and solutions not just for motorsport, but for motorsport as a lab for future road mobility."

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WHAT THEY SAID...

DR VALERIA LORETI
Delivery Manager Motorsport, Fuels Technology Group, Shell Global Solutions (Deutschland) GmbH

"Participating in WMS 2024 was not only a great opportunity to hear directly from technical experts on a number of relevant and stimulating topics, but also the opportunity for networking and establishing those key relationships that are the basis for further development and exciting breakthrough steps."

DAVID SALTERS
President of Honda Racing Corporation USA (HRC US)

"I really appreciate the effort that goes into the Symposium, the straightforward open discussion, informed debate and reflection."

ERIC JACUZZI
Vice President, Vehicle Performance at NASCAR

"Another great learning experience for the two of us that attended from NASCAR. The topics were very relevant to the future of motorsport, and challenged us to look deeper into some areas of development that we had not previously considered or perhaps considered seriously enough. As always, the collegial atmosphere and lively debates and conversations make for a great event. I am looking forward to seeing everyone again next year and hearing about the advancements another year brings."

ULRICH BARETZKY
Former Director, Audi Motorsport Engine Development, Audi AG

"The 2024 WMS in the famous Royal Automobile Club was very special, a real highlight to mark the event's 20th anniversary. The quality of presentations, as well as the respective discussions in this very special atmosphere, really makes me look forward to the 2025 event."

ALAN PATTERSON
Founder, BeyondMath

"WMS is the one event that brings together all the leaders in motorsport under one roof. As a startup, this is invaluable for us."

SERGE GRISIN
Motorsport Director, Symbio

"I was truly impressed by the quality of the discussions, the insightful exchanges with leading experts in motorsport and technology, the spirit of openness and constructive dialogue, and the overall sense of shaping not only the future of motorsport but also, and more importantly, the future of mobility. A future that aspires to be more sustainable."

ASTON MARTIN
aramco
cognizant

LEFT Pit stops are one of the areas AI will be harnessed for, looking at the development of intelligent wheel guns, automated jacks, and release light systems

ARMED AND DANGEROUS

Arm's innovation powers more than 300 billion devices worldwide, from smartphones to supercomputers, so how will a new partnership help the Aston Martin Aramco F1 Team fight for glory? **Chris Pickering** finds out

PARTNERSHIPS are an important aspect of Formula 1. Such is the pace of competition that F1 teams tend to shun off-the-shelf components and develop their own equipment wherever the rules allow. Teams have been known to modify wheel guns and even 3D printing machines when they sense an opportunity to tailor them to their own unique requirements.

And yet the underlying technology used in the devices designed or modified by the teams still has to come from somewhere. Increasingly, this is forging links further up the supply chain, with the teams going directly to the likes of cell manufacturers, cloud computing specialists and silicon chip developers.

Aston Martin Aramco F1's recently-announced partnership with Arm is a case in point. Named as the team's official AI compute platform partner, the tie-up will cover areas like hardware selection and the utilisation of AI. The two organisations are also keen to use it to promote a more inclusive and equitable future in motorsport and STEM, highlighting issues such as the lack of female engineers.

"Whenever we're bringing up new technology, it takes a long time to choose what platform you're going to use. So, with this partnership, Arm can introduce us to new chips and new technologies that we wouldn't necessarily have the time to delve into," explains Aston Martin Aramco F1's head of electronics, Charlie Blackwall. "This is particularly relevant when it comes to AI. It's an area that we're using more and more, and we can tap into Arm's expertise and knowledge to streamline our process for introducing new algorithms and processes."

For Arm, it's a chance to take a deep dive into how the company's technology is being used in one of the most demanding engineering environments on the planet, plus a showcase to inspire the next generation of engineers.

"When you look at the car, there's over 300 sensors, 5,000 points of data, 3 TB of information in one race. It's an amazing engineering feat," says Dipti Vachani, senior vice president and general manager for automotive at Arm. "The data collection, the data centre and many of the sensors are Arm-based. So, this is an opportunity for our engineers to see the technology that they work on manifested in reality. It puts us in direct contact with the team to ask how is our technology being used? How can we improve it? How do we make it more efficient?"

> *"It doesn't matter how much money you've got in F1, you can't buy time. AI can help us be more efficient"*

Targeted processing

Arm is a developer of processor IP. The company doesn't manufacture its own chips, but it develops the underlying technology that is then licensed to some of the biggest names in the semiconductor industry. Part of that IP focuses on understanding how processors can be tailored to particular applications, such as AI.

All processors rely on an instruction set architecture (ISA). This is an abstract model that defines the set of instructions that the processor can understand and execute, ▶

such as arithmetic, logical operations and data movement. In effect, it sets out the processor's capabilities and defines the areas where it will function most efficiently.

"AI is a very math-intensive workload," comments Vachani. "A general-purpose CPU is made to do a lot of things, but when you optimise it to doing math, you can do it a lot faster and with a lot less power. This is why it's so important to understand the application – when you really understand the work, you can optimise the processor."

The other aspect to optimising computers for AI is efficient data processing, she explains: "You need to get the data in a certain format, so the math can actually work. Often that data pre-processing takes place on an Arm CPU before it goes through to one of our GPUs to accelerate the AI workload."

Picking the right ISA is not just about how the device processes data internally, but how well it interfaces with other devices right up the chain from the sensor on the car to the data centre in the cloud.

"Something we brought to the table was the importance of ISA parity," explains Vachani. "If you have ISA parity [between the processors along the chain] and you understand how the implementation is done in the car and how the implementation is done in the cloud, there's no translation that has to happen on that data. That data stays in one environment. It is collected off an Arm processor, and now that environment is the same in the cloud. If it's not the same, it has to go through translation, which can introduce delays or inaccuracies."

BELOW & RIGHT
Jessica Hawkins made headlines in 2023 when, driving an AMR21 in Hungary, she became the first woman in nearly five years to test a modern Formula 1 car. She will represent Arm as an Official Ambassador, championing opportunities for women in motorsport

> *"We're regulated on budget, wind tunnel usage and CFD usage, but I don't know how you could extend that to AI"*

Weight reduction

Blackwall says he has a number of AI-based projects that he's keen to undertake with Arm. One of these is to eliminate the sensor currently used to physically measure lateral slip and replace it with a model-based approach using data channels that are already on the car.

"We use the same speed-over-ground sensor that all the teams use, but it weighs about half a kilo," he explains. "The plan is that we can develop a model that estimates the sideslip angle from other inputs in the cars, such as the accelerometers, the wheel speed sensors and the gyro. You can build a model that estimates the sideslip angle based on those other parameters and gives you that figure in live telemetry.

"The idea is that with Arm, we can either use that to build a black box model from scratch and then put the right boundary conditions in, or we can use their technology to parameterise the models that we already have and improve the validation of those models compared to real-world data."

On the face of it, this seems like a relatively simple parameter to calculate – the sort of exercise that you might see laid out theoretically in a vehicle dynamics textbook. In reality, however, it's a complex ▶

Driving diversity

IN THEORY, motor racing is the ultimate meritocracy. An environment where those with talent and determination rise to the top, irrespective of their background. And yet, it still faces much the same diversity challenges as other areas of engineering.

There are initiatives across the industry to make motorsport a more inclusive environment and it's something that Aston Martin Aramco F1 and Arm are working hard to promote with their partnership.

Arm's Dipti Vachani studied computer science. "I was the only woman in my graduating class," she recalls. "The environment is very similar in Formula 1. If you look at the drivers, there's very little diversity and no female drivers at all on the current grid."

There's clearly a long way to go, but there are a growing number of women in high-profile engineering roles in Formula 1. Red Bull's principal strategy engineer Hannah Schmitz is coming into the new F1 season off the back of a fourth consecutive drivers' championship for the team. Former Aston Martin Aramco F1 race strategist Bernie Collins has rapidly established herself as one of the sport's key voices as an analyst on Sky's international TV coverage. Meanwhile, Aston Martin Aramco F1 driver ambassador Jessica Hawkins made headlines in 2023 as the first woman in nearly five years to test a modern Formula 1 car.

"Meeting Jessica was very special to me, because I saw that the challenges she faces are very similar to those that I have experienced from my career in this industry," says Vachani. "And so another element that came out of this partnership was to ask, 'how can we help?'"

Aston Martin Aramco F1 has an active mentoring scheme, not just engaging with female engineers, but also those from lower income and underprivileged backgrounds.

It's a particularly relevant topic with the rise of AI, Vachani points out: "When there's a technology that's as powerful and pervasive as AI is going to be, it's a once in a lifetime opportunity. We've got to start working on creating inclusivity and diversity in our businesses today to make sure that it works for everyone. To give you an example, I find that the automatic handwashes you get in places like airports often don't work for me, because they weren't developed for darker skin. The way that you address those problems is to have everyone involved from the start." RT

RIGHT Sky analyst Bernie Collins is a former strategy engineer for the Aston Martin Aramco F1 Team

Courtesy of F1

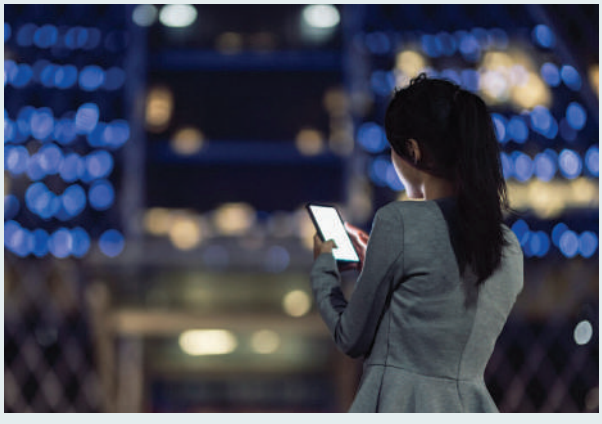
Back to school

ARM sits at the cutting edge of CPU technology, with 43 offices in 21 countries developing and licensing technologies used by the likes of Apple and Samsung. In fact, there's almost certainly a smartphone or another device with Arm technology in the room you're sat in currently. And yet this global giant's origins will be surprisingly familiar to many in the UK.

The company began as a spinoff from Acorn Computers, the Cambridge-based firm tasked with building the BBC Micro computer, which was a fixture in almost every British classroom throughout the 1980s and 1990s. As part of this programme, computer scientists Sophie Wilson and Steve Furber developed a RISC-based instruction set (ISA) architecture dubbed ARM1. The aim was to produce a CPU that offered low costs, low power consumption and low heat generation.

A new company known as Advanced RISC Machines – abbreviated to Arm – was spun off from Acorn in 1990 and set up in a former turkey barn in Cambridge. The company's breakthrough was to adopt an IP-based business model, licensing its technology for an upfront fee followed by royalties on each chip produced. This really came into its own when the mobile phone market started to take off in the mid-1990s, with market leaders Nokia using Arm's technology in its hugely successful 6110 GSM handset.

Mobile phone processors need to be small, light and capable of running off a battery. These requirements shaped the company's design philosophy and that legacy can still be seen today in applications like Formula 1.



LEFT Arm-based chips power around 99% of premium smartphones

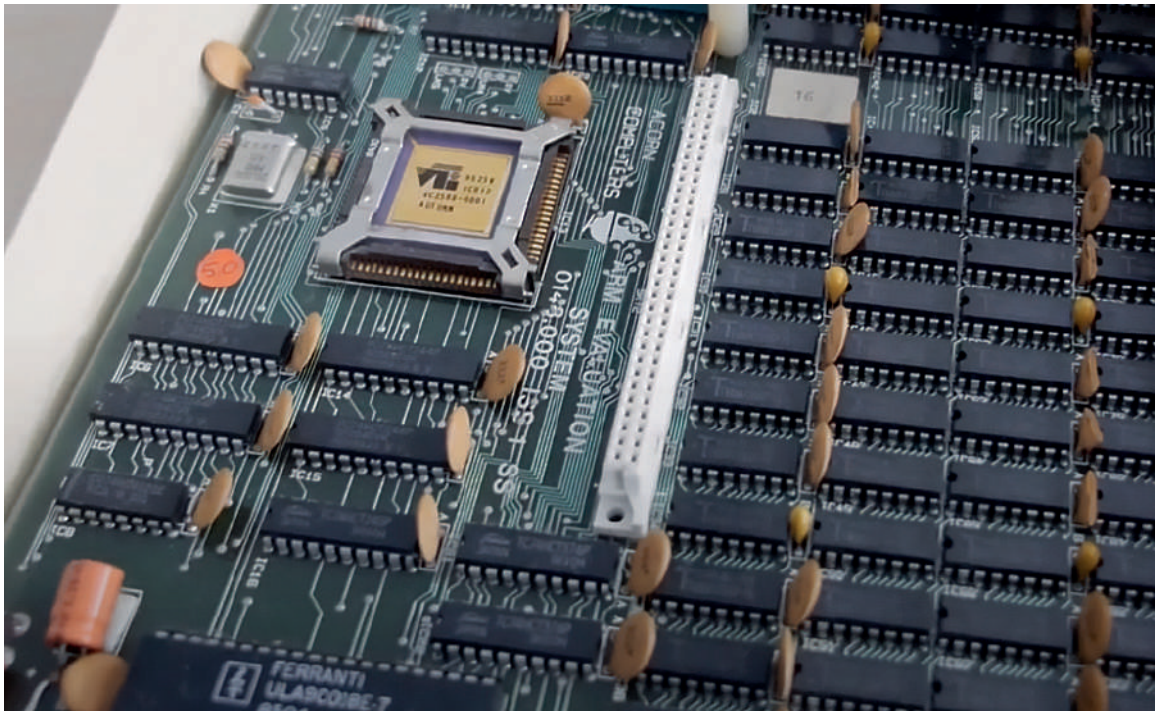
multi-dimensional problem.

"The slip angle is dependent on a host of factors like tyre grip, vertical load, steering angle and lateral acceleration," says Blackwall. "Initially you think, 'oh, I can just integrate lateral acceleration', but all sorts of discrepancies creep into the data. You have differences depending on where the accelerometers are located relative to the car's centre of gravity; measurements from the accelerometers are affected by the way the car pitches and rolls; you have longitudinal wheel slip as well, which then adds another factor. That's why we use an optical sensor to measure it, but obviously we'd rather take that mass out of the car."

Aston Martin isn't the first team to attempt to tackle this problem with AI, but Blackwall is sceptical as to whether the previous solutions have delivered the required accuracy. He's hoping that the forthcoming project with Arm can change that.

Sorting tasks

Formula 1 teams have been using various branches of AI for data analysis for upwards of a decade. One of the more basic examples is categorising images. All Formula 1 teams take huge numbers of photographs of their competitors' cars. Traditionally, a junior member of the team would be lumbered with the job of sorting through these and labelling them – for instance, identifying which car was shown in the shot and then tagging individual photos that feature key details, such as the floor, the wings or the brake ducts. AI can now be trained to do this automatically, freeing up the technical staff for other jobs.



LEFT It's hoped the use of AI will help the team approach the aerodynamic challenges of the 2026 car as efficiently as possible

RIGHT The company began as a spinoff from Acorn Computers, building the BBC Micro computer which was a fixture in many UK classrooms

Another area where AI is employed to sort and filter data is images from the wind tunnel. The team uses particle image velocimetry (PIV), where tiny tracer particles are seeded into the airflow and then illuminated with a strobe light or a laser to visualise their path over the car.

"You get discrepancies when you take a PIV image, such as unwanted reflections and edge cases where the light aimed at the particles isn't reflecting properly," explains Blackwall. "Previously, we spent hundreds of hours trimming out areas and evaluating how much of what we had was useful data. Now we can train a model to do that for us, which saves a huge amount of time. And it doesn't matter how much money you've got in F1, you can't buy time. So, we've got to be efficient. And AI helps us with that hugely."

> *"Over 300 sensors, 5,000 points of data, 3 TB of information in one race"*

These are typical of the applications where AI is used at present. It's generally much focused on eliminating repetitive tasks, so the engineers' time can be freed up to focus on developing and optimising the car. While some have concerns around the use of AI, Blackwall is firmly of the opinion that it will assist engineers rather than displace them.

"With the best will in the world, AI algorithms aren't in a position to design a Formula 1 car, they can't even draw hands," he quips. "What you might do is take your CFD data with a series of very coarse points and train a model to fill in the gaps. That might give you an idea of where the optimal point lies so you can go back and do a really detailed simulation around that point. It can certainly speed up the progress, but it's only as good as the data you use and how you apply it. You need to use it very intelligently."

AI regulation

There's no doubt that AI represents a powerful tool, and potentially a competitive advantage to teams who can harness it most effectively. This is a significant undertaking, as witnessed by the fact that all the teams – Aston Martin included – now have tie ups with major cloud computing providers.

Perhaps the beauty of AI will turn out to be that its efficiency benefits allow smaller teams to pursue innovations that they don't currently have the resources to tackle. But there's also a fear in some quarters that it could go the other way and play into the hands of the bigger, richer teams.

The FIA and Formula One are known to be looking into the use of AI, but it is not regulated in any way at present. Speaking to Italian newspaper *Corriere dello Sport* last year, Formula One CEO Stefano Domenicali commented, "We have promised to understand how much [AI] can influence performance, because we still don't know enough to intervene".

As things stand, Blackwall says he doesn't see it as an issue: "We're regulated on budget, wind tunnel usage and CFD usage, but I don't know how you could extend that to AI, because it's such a broad term. You're talking about neural networks, machine learning, deep learning... It would be very hard to regulate it with a blanket term like 'AI'. A lot of the things that we use are ▶

BELOW Team principal Andy Cowell says the team were world champions for updates in 2024 but many, such as the Austin upgrade, didn't bring the desired performance. With Arm now an Official AI Compute Platform Partner, a more efficient approach is targeted this season

just statistical models, basically, so I don't think it's that different to having someone cycling through the data manually, but that might change depending on how things evolve in the future."

A key point is that the F1 budget restriction includes third parties. All work has to be costed, even if it's done by a sponsor or a technical partner. If the FIA had any concerns about transparency, it could request an audit to ensure that everything was being done on proper commercial terms. In theory, at least, this puts all teams on a level playing field to exploit AI intelligently rather than simply throwing money at the problem.

New challenges

Formula 1 teams are constantly chipping away at innovation, but the significant technical shake-up coming with the 2026 regulations means there will be even more to play for.

Aerodynamic development for next year's car began in January (prior to that it was prohibited by the FIA's restriction on CFD testing for 2026) and it's hoped that AI will help the team to approach this as efficiently as possible.

"Developing the car is always an iterative process," comments Blackwall. "You go through the CFD loop until you have something you take to the tunnel, and then you go back again, crank the handle and, eventually, out pops an F1 car at the end of it. What we need to do is compress that."

One of the things that AI can do is fill in the blanks. For instance, flow velocity is very easy to measure in the wind tunnel, but pressure is more time-consuming as it requires the team to build a rake that will fit around that particular iteration of the car or the model. CFD simulations are faster to generate and they can be used to extract both pressure and velocity, but they are not always as accurate as the tunnel. By combining existing well-correlated data from CFD and the wind tunnel, the team can teach an AI model to predict the pressure distribution based on the velocity readings from subsequent wind tunnel runs. This fills in the missing information, giving a full set of data for both the CFD simulation and the wind tunnel, allowing the team to establish the correlation.

"We can take that a step further and look at the correlation between the CFD, the wind tunnel and the car," comments Blackwall. "Obviously, you can't measure velocity on

> *"I want to get AI to the point where more people can use it and learn how to use it well"*

the car, but you can use a rake to measure pressure and then you can see how the whole thing correlates. That's not something we've been able to do for 2026 as we're not allowed to do any track testing yet, but that's the sort of way that we can employ AI in those scenarios."

Vast improvements in computing power and cloud access are pushing AI into the mainstream, with everything from predictive text on your phone to the personalised TV recommendations on Netflix harnessing this technology. Similarly, AI is becoming far more accessible in engineering, with user-friendly tools now aimed at development engineers rather than dedicated data specialists.

"I think accessibility is going to be the key," comments Blackwall. "I want to get it to the point where more people can use it and learn about how to use it well. I think it could also be very useful for simulation – both for constructing the vehicle models and the tyre models, and for correlating those with the data on the track. We could use it to see where the model is doing a good job and where it's less accurate.

"If your simulations are better, you can then do more in the software environment before you have to cut in the metal. And then when you do start making physical prototypes, you want them to be better, quicker, so you can get them out to the races sooner. That's the name of the game."

The huge investments that Formula 1 teams make to develop these tools and skills in-house are not to be underestimated. It will always be one of the most self-sufficient forms of motorsport, with constructors generating much of their own IP. And yet strong partnerships with companies like Arm could play a pivotal role in unlocking that innovation.

ABOVE Jessica Hawkins with Dipti Vachani (SVP and general manager for automotive at Arm), and Charlie Blackwall, the team's head of electronics

BELOW News of Arm becoming Aston Martin Aramco's official AI Compute Platform Partner was broken at CES in Vegas

THE LESSONS OF 10 YEARS AT THE TOP

From the hybrid rocketships of 2014 through to today's golden era, endurance racing has changed almost beyond recognition – yet Toyota remains the benchmark. **Damien Smith** talks to one of the key architects behind the manufacturer's success

WHEN Sébastien Buemi crossed the finish line at the Bahrain 8 Hours back in November to seal a famous comeback victory – the Swiss had only been 10th with just over an hour to go – it was enough to confirm a sixth consecutive manufacturers' crown for Toyota in the World Endurance Championship.

The team might have tasted defeat at Le Mans for the second consecutive year at the hands of Ferrari, and one of the Penske Porsche Motorsport crews clinched the WEC drivers' title, but Toyota GAZOO Racing remains the benchmark in terms of consistent achievement. This is a racing team built around an intrinsic understanding of what it takes to win world titles.

The latest prize for the Toyota GR010 Hybrid Hypercar followed exactly 10 years on from Toyota's breakthrough year in the modern iteration of the WEC. Back in 2014, during the height of the LMP1 prototype era, the Japanese giant finally achieved its aim of defeating mighty Audi to secure a manufacturers' and drivers' WEC title double, the latter courtesy of that man Buemi – surely Toyota's finest servant in long-distance sportscar racing – and Anthony Davidson.

Today, its TS040 is recalled with misty-eyed nostalgia, both by its drivers and its engineers, as part of a family of sports prototypes that represent the apogee of the breed in terms of technical sophistication and speed. The WEC is far healthier now, thanks to the dizzying line-up of manufacturer entries it boasts in this strictly controlled era of Hypercar racing. But the relative freedom of the high-tech – and unsustainably high-spending – LMP1 days will never be forgotten.

Changing breed

David Floury has seen it all. Toyota GAZOO's current-day technical director was the chief test and race engineer back in 2014, employed by then-partner ORECA for whom he also served as technical director. He is one of only three on the Toyota

All photos: Toyota GAZOO Racing

ABOVE & RIGHT
The TS040 (left) was conceived at the height of LMP1's space race; the more cost-conscious GR010 HYBRID became the first World Champion powered by 100% renewable biofuel

programme to have played a hand in every WEC race since the modern championship was founded in 2012. No one is better placed to offer a contrast on how the WEC breed has changed.

"The LMP1 technical regulations clearly had more freedom and we had very little restriction in terms of homologation and development, unlike now," says the Frenchman. "Basically it was a case of continuous development back then and we would generally produce a new car every year. We'd often keep the same survival cell, but most of the car was new or at least a significant development from the previous year."

He says the TS030s of 2012/13 and the TS040s of 2014/15 were all individual cars despite the designation carry-over, until the TS050 of 2016 marked a step change as Toyota switched from a capacitor to battery hybrid system and from a normally aspirated to turbocharged engine. Iterations of the TS050 then served Toyota through to the birth of the Hypercar era, when for the first two seasons a 'grandfathered' ▶

version kept the car maker's run of success going until the GR010 was introduced in 2021.

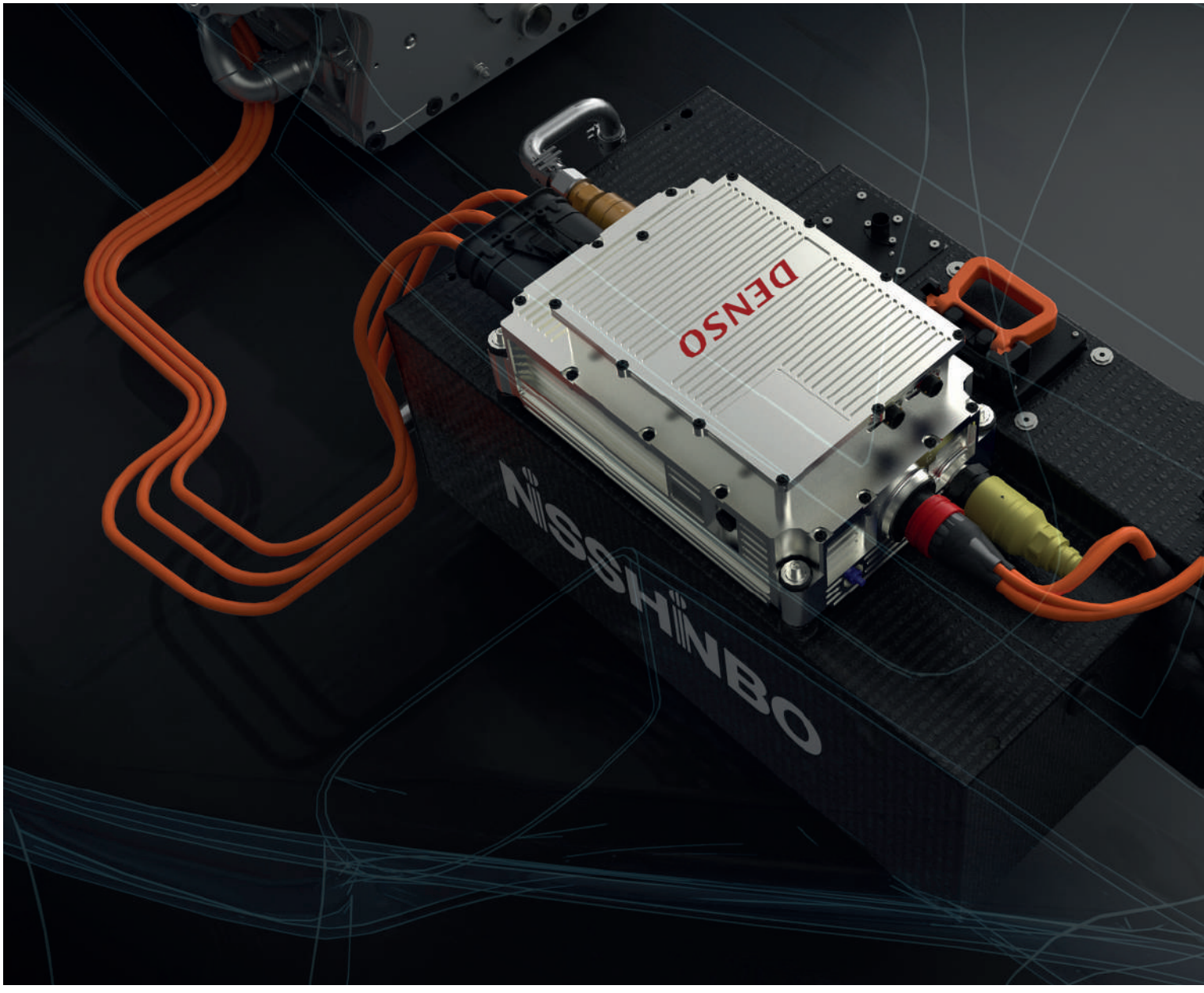
LMP1 was a different world. Even now Floury won't disclose what Toyota used to spend on its WEC campaigns, but does admit "the order of magnitude was between two and three times higher than currently. Probably close to three times higher. And at the time we were clearly not the ones spending the biggest budget."

The TS040 of 10 years ago bristled with technology that has been pared back in the Hypercar era to avoid what amounted to a spending war that eventually led to LMP1's demise, after first Audi and then Porsche quit to leave Toyota essentially unopposed. Pioneering hybrid systems were at the heart of the era, as Floury explains.

"The hybrid system had two advantages," he says. "One was the recovery and regen of power to increase and boost the output, and by doing this we developed our own strategies to achieve the best lap time. Then beside this there was a lot of scope hybrid enabled in terms of controlling vehicle dynamics – it could be a brake system, but also managed traction control, engine braking and the diff. So it was quite advanced."

> *"The way motorsport is used is not only about transferring technology, but also the culture and approach"*

Where today's Hypercars exist on the sacred covenant that is Balance of Performance, LMP1 ran to the Equivalence of Technology philosophy.



BELOW The TS040's hybrid system employed a Denso motor/generator on the rear and Aisin motor/generator at the front to provide power to all four wheels. The hybrid's 480 hp contributed to a total of 1000 hp

ABOVE The totally new TS040 HYBRID for 2014 was developed with a bigger 3.7-litre engine and 520 hp output, despite a 20% reduction in fuel consumption. The team won five of the eight races to sweep the titles

The difference is more than just semantics, as Floury explains. "EoT was trying to equal different technologies but only looking at the technology potential, and mainly regulating the input. BoP is basically trying to equalise the output and regulating it. It's a completely different philosophy.

Hybrid incentive

"EoT between our petrol engines and the diesels such as Audi's was spot on, but there was also a small incentive to push people to develop hybrid systems, and therefore we had different classes," Floury explains. "You could come with no hybrid system, then you could have 2, 4, 6 and 8 MJ classes. It was based on the maximum energy you could boost in one lap at Le Mans, which was derived with a coefficient factor and the ratio between the track length for the sprint races. The incentive was to develop towards the highest category of 8 MJ. We had a 300 kW boost limitation, but then the other limitation was on fuel flow through a fuel flow meter. These were the main limitations we had, and after that we were free to develop. The input, especially the energy, was restricted, but how you used it was quite free and obviously the hybrid system was a big part in delivering the performance so that became a main focus in terms of development.

"We also had much more freedom in terms of suspension, to control the car's platform – the use of a mass damper, for example – and the connection between the axles. The aero was a big part and we were really advanced on engine combustion ▶

technology to optimise the efficiency. We were reaching a really high level on that. These elements" – hybrid, suspension, aerodynamics and engine combustion – "were the four pillars to develop LMP1 car performance."

The evolution of hybrid technology began back in Japan, says Floury. "Initially we had prototype cars running in Japan to evaluate hybrid systems in racing and this is similar to what we see with the hydrogen-powered Toyota Corolla H2 which is racing in Super Taikyu right now," he says. "Back then, at first we had a Supra and then a sports car based on a customer chassis to evaluate hybrid technologies. Only the Supra actually raced. From there, we started the project [in 2012]. Initially we based it on the expertise developed in road car R&D and through the year we pushed the boundaries to extract more and explore new technologies. This fed back into the road car R&D.

"The philosophy at Toyota is always to develop the expertise to make better cars, but also to develop people," he stresses. "Through all the years in the WEC programme we have had quite a lot of rotation in terms of personnel. We have engineers or mechanics joining for stints which can be one, two or three years, then they go back to road car development with all that they have learnt from their motorsport experience. The way motorsport is used is not only about transferring technology, but also the culture and approach." ▶

ABOVE & BELOW As costs have decreased, the amount of competition has increased. Last year's series (below) featured nine Hypercar manufacturers, but evolved into a three-way title battle between Ferrari, Porsche and Toyota GAZOO Racing. Ten years ago (above), Porsche and Audi were the only serious opposition, but their challenge was formidable

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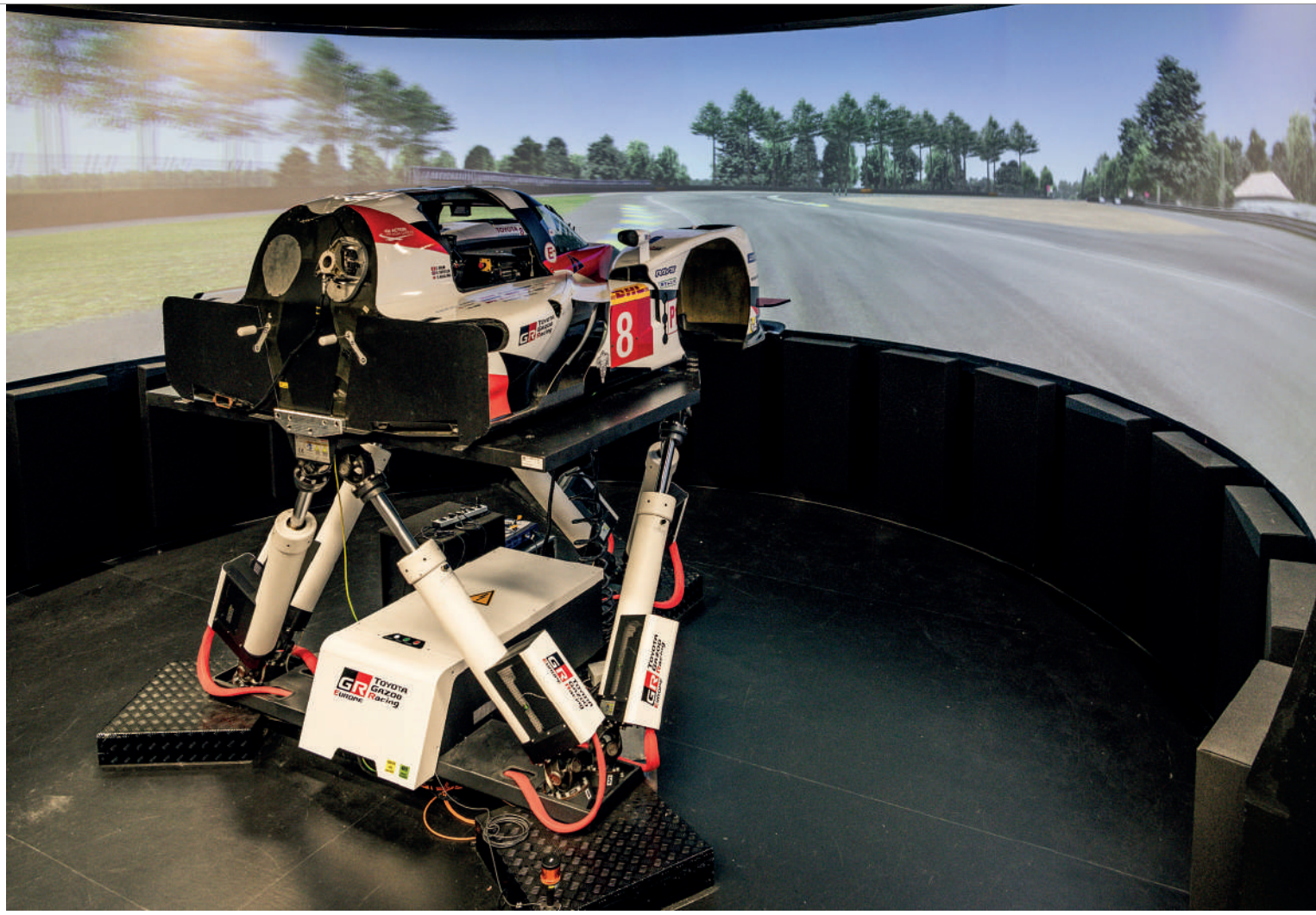

You sense Floury looks back on the LMP1 days with great affection. "Yes, it was definitely a great period," he admits. "From an engineering standpoint it is probably the best category I've been involved with. It is the case for most of us. In some aspects it was more interesting and relevant than Formula 1. But unfortunately the development costs were also high and therefore the category turned out not to be sustainable. It's a shame because these cars were really great. But you have to be realistic and a new direction was needed. The ACO, FIA and IMSA worked hard on that and it led to the Hypercar era we now live in."

Joker system

How does Floury summarise the differences between LMP1 and Hypercar? "One of the key factors of the Hypercar regulations is a clear target to reduce the cost," he replies. "The philosophy was to keep the technology as much as possible while limiting the cost, which was definitely not easy to achieve. It has been achieved mostly in two directions. One was to limit the amount of development you can do, so we have long homologation periods for the cars with heavily restricted developments possible during these periods. We only have five jokers to play in the homologation period, so the development is not as regular as what we used to have in LMP1."

ABOVE Toyota GAZOO Racing was an early adopter of DiL simulation. Its prowess in this field played an ever-increasing role as cost caps began to bite

There has also been a crucial change of emphasis on performance controls. "While LMP1 was about controlling the input, the energy you can use, Hypercar limits the output which means all cars are tested by the FIA, ACO and IMSA in the windtunnel and have to enter an aero performance window, which means all cars are pretty close on downforce and drag," says Floury. "This leads all cars to have similar performance on track and this also limits the amount of development." There's little point in car makers investing in endless aero development if the rule-makers vigilantly peg back any gains.

"Other parameters are measured live while the car is running," continues Floury, "especially the power and torque outputs which are measured through driveshaft torque sensors. This regulates the output and the level of power you can use is defined in the BoP table which tries to balance the performance between the cars, as does the weight. This limits costs, yet we are still using advanced technology." ▶

> *"The essence of human nature is about pushing boundaries, exploring and competing"*

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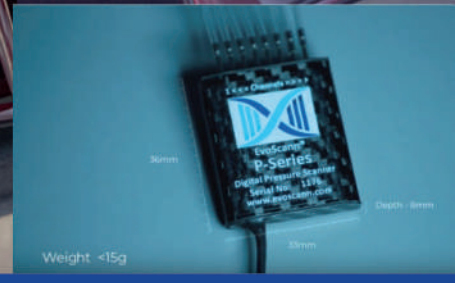

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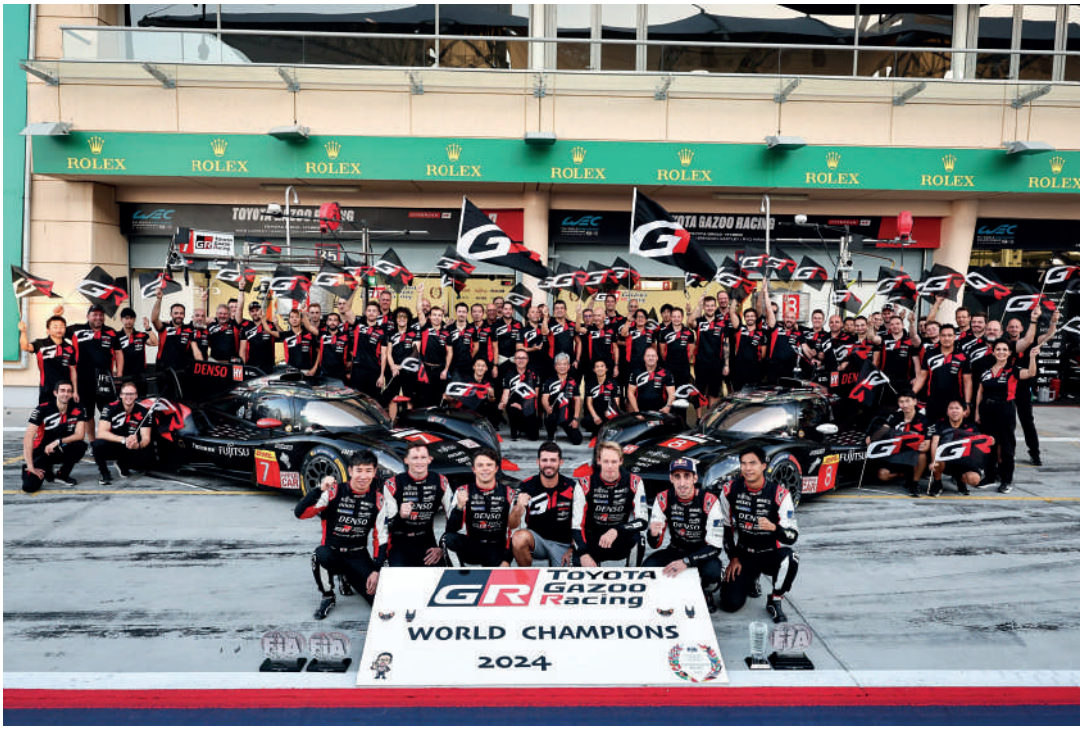
Technical restriction always creates a focus on minute details that can make all the difference. But the BoP era also enhances the importance of team functionality, how it operates – which is where Toyota's vast WEC experience over 12 years comes into play. Victory in 2024 at Imola, on a day pace-setting Ferrari made the wrong strategy call in changeable weather, was a prime example.

As for the hybrid systems now in use, Floury explains how detuned they are. "The Hypercar system is less powerful," he states. "In LMP1 we were limited to 300 kW boost power, now we are limited to 200 kW. We use only one MGU in Hypercar, while in LMP1 we were allowed to use two. The weight of the components is regulated in Hypercar while in LMP1 you could push the limit and try to reduce it. The deployment speed also in Hypercar is part of the BoP table. Below a certain speed you cannot use the hybrid system to apply positive torque to the wheel, while in LMP1 you could boost as early as you could."

A variance in this regard exists between the LMH rules the GR010 is built to and the rival LMDh cars such as



BELOW LEFT Ten years on from that first world championship success (bottom), Toyota underlined its position as the enduring benchmark for rivals

BELOW The team entered last year's finale in Bahrain trailing Porsche by 10 points but staged a tremendous fightback to pip the German squad to the manufacturers' crown by just two points

the Porsche, BMW and Cadillac. Whereas LMDh cars with their rear-mounted off-the-shelf MGUs can apply their boost without a speed limitation, LMH entries and their front-mounted MGUs can only use their extra power boost at and above 190 kph – as per the BoP table – thereby essentially nullifying the advantage of their four-wheel drive activation.

Hydrogen horizon

Next on the horizon is hydrogen technology, which Toyota is investigating seriously as an option for future WEC campaigns. "It's definitely an interesting technology," says Floury. "At Toyota the strategy is clearly towards multiple paths, not just looking into a single technology. Some manufacturers committed massively to BEV cars with a single strategy. At Toyota the idea is to evaluate different technologies and also use them as needed.

"Clearly the target is to reduce CO2 emissions and converge to zero. How you achieve this is likely to be different depending on application and also the customer profile and where you are around the world. Hydrogen is a big challenge in many aspects and probably a bigger challenge than developing the hybrid 12 years ago."

So we come to the final and hardest question: predicting the future. Ten years ago Floury and his colleagues could never have envisaged the convergence we see across WEC and IMSA today, for what Floury describes as a "golden era of sportscar racing". Who knows where we'll be in another decade from now? Still, Floury is optimistic.

"Since I've been involved in motorsport I keep hearing that I should enjoy it because the future is not that bright," he says. "But the essence of human nature is about pushing boundaries, exploring and also competing. Motorsport covers all of this. I am quite optimistic. The question is not whether motorsport will still exist, but how it will adapt and develop to be relevant. Along with developing a CO2-neutral society, we need to keep bringing happiness to people. We also need to consider this." RT

IMSA'S GT REVOLUTION

IMSA technical director Matt Kurdock explains how the introduction of torque sensors is transforming the quest for parity in GT racing. By **Chris Pickering**

CHARACTER is a hard thing to define. With cars, so much of this ineffable quality that we ascribe to them comes from being noticeably different from the rest of the pack. A high-revving naturally aspirated engine that cuts through the more muted turbos or the characteristic silhouette of a rear-engined car among its front-engined counterparts.

It's this variety sprinkled with some illustrious names and a healthy dose of road relevance that makes GT racing so compelling. Nowhere else will you see a V10 supercar, a thunderous V8 muscle car and a six-cylinder sports saloon competing together on equal terms.

But that parity doesn't come easily. In theory, if you cap the maximum power output of the cars with traditional methods like air restrictors and boost limits, you will reach a point where they all record the same lap time. But only for that particular lap, on that particular circuit and under those specific atmospheric conditions. And even then, the likelihood is that further tweaks will be needed to equalise things like fuel consumption and pit stop times.

With the introduction of vehicle-mounted torque sensors, the balance of performance (BoP) process has taken a giant leap forward. First seen in the LMH category of the World Endurance Championship (WEC) in 2021, the technology was adopted by IMSA's LMDh formula the year after. The WEC's LMGT3 class followed in 2024. And now it's the turn of IMSA's GTD and GTD Pro categories.

The two GTD categories (we'll drop the Pro distinction from here onwards...) both work to the FIA GT3 regulations. IMSA uses its own BoP process and its own logging hardware, although the sensors, supplied by Californian firm MagCanica, are identical to those used in the WEC and the system follows the same basic principles.

"The driveshafts have to be made out of a specific alloy of steel that is then magnetised in a very controlled process by the torque sensor manufacturer," explains IMSA technical director Matt Kurdock. "When a torsional stress is applied to the driveshaft, it creates a change in the magnetic field. There's an array of magnetic transducers around the driveshaft that detect this change wirelessly and sends that information to our onboard scrutineering logger."

This method is made possible by a detailed calibration process that takes place on the test bench over a variety of temperatures, allowing the sensor to infer the torque applied to the driveshaft from its torsional behaviour. The IMSA scrutineering logger that reads the data is effectively a standalone ECU, which also collects information from a dedicated engine speed sensor and an array of dedicated wheel speed sensors. Armed with the engine speed and the torque, the logger can calculate the power output, which is also fed back to the IMSA officials via live telemetry.

> *"It's a technology that allows us to regulate power and that's a game-changer"*

A series of filters allow for transient spikes due to things like wheelspin over the kerbs or torsional effects in the transmission. Any excess power is integrated as a function of time, so potential penalties consider both the magnitude and the ▶

RIGHT The Rolex 24 At Daytona ushered in a new era for IMSA, with the use of torque sensors extended for the first time to the GTD ranks

All photos: LAT USA

duration of the transgression. Teams could be issued with a warning, a drive-through penalty or something more severe, depending on the circumstances.

The sensors tend to be installed roughly halfway down the driveshafts (one for each driven wheel) as this places them further away from other sources of magnetism but the installation is up to the individual teams and manufacturers.

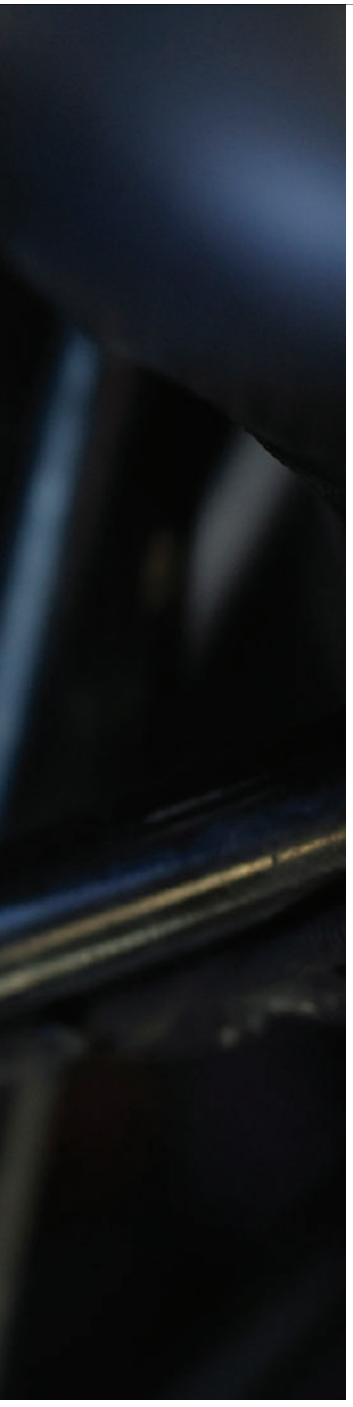
Unique profiles

In IMSA's GTP category, and indeed in LMH, there's a nominal maximum power curve that the manufacturers have to follow. The curve is scaled to fit each car's maximum engine speed, and it can be adjusted up or down by 20 kW for performance balancing.

In GTD, the situation is rather different. It would be virtually impossible to find a common torque curve that would work for the huge range of different production-based engines used in this category. Instead, IMSA invites each manufacturer to define its own unique torque curve, including its own maximum power figure. A set of BoP tables is then used to scale the whole curve up or down for individual vehicles.

"The BoP adjustment refers to each car's maximum power curve. So, if you see one car that's on 100 per cent and another that's on 90 per cent, it doesn't mean that there's a 10 per cent power difference between them. You can't compare across manufacturers, but we found that we

> *"The virtual fuel can 'run dry' while still retaining enough fuel in the physical tank to bring it back to the pits"*



LEFT MagCanica's Ultra High Accuracy (UHA) driveshaft torque sensor system enables the rule-makers to regulate power

were able to give the BoP process some structure and implement simple changes this way," comments Kurdock.

The flexibility built into this process has already proved useful, but Kurdock admits that there hasn't been as much variation in the engines' power characteristics as he was expecting: "If you're a manufacturer, I suppose you're looking for a blend of reliability and drivability, with a torque curve that fits the gearing that you've homologated for your car. There's not as much variation as we thought there might be, but we still need to balance naturally aspirated cars against turbo cars, which is something we've always been battling with."

Dual stage power

The second major BoP tool made possible by the introduction of torque sensors is what IMSA terms dual stage power. Essentially, each car has two torque curves. One for speeds below 190 kph and one for speeds above that. GTP has a similar thing, but the crossover speeds for the prototypes is slightly higher at 230 kph.

"Having two different power curves gives us the ability to adjust the initial phase of acceleration and the more terminal phase of acceleration separately," Kurdock explains. "Our hope is that we'll be able to really close down on the straight-line performance characteristics of all the cars. IMSA has already shown that we've been able to balance the cars to a very narrow margin in terms of lap time, but sometimes at the sacrifice of a wider margin in terms of top speed. With dual stage power, our hope is that we're able to reduce the margin on the top speed and how that top speed is achieved while maintaining appropriate lap time balance."

Again, the two torque curves are essentially the same curve just scaled to different BoPs. For instance, the car might operate at 95 per cent of its manufacturer's defined torque curve at low speeds and then switch over to 98 per cent once it goes past the 190 kph threshold. ▶

RIGHT Power output is fed back to the IMSA officials via live telemetry. Here IMSA technical director Matt Kurdock scans the screens

DPPI/WEC

> *"Having two different power curves gives us the ability to adjust the initial phase of acceleration and the more terminal phase of acceleration separately"*

The expectation is that the new BoP system will prove particularly useful for longer races, starting with the Rolex 24 At Daytona.

"At Daytona, we can see a pretty significant change in ambient conditions over the course of the race," notes Kurdock. "It's run in the winter, so it can be quite cold at times, but over 24 hours we can also see debris on the track starting to plug up radiators and intercoolers. From what we've seen in GTP, it's led to more consistent performance across the race."

In theory, blocked intakes could result in a situation where the car can't physically make the maximum power that it's allowed to achieve, but Kurdock says the hope is that all manufacturers have enough margin to prevent that from happening.

"A day prior to The Roar and a day prior to the Rolex 24 event, we'll take the ambient conditions at the track and we'll use that to calculate what a correction factor needs to be," he says. "We'll publish a technical bulletin to everyone with the correction factor. So, basically, we'll adjust for the ambient conditions to make sure that everyone can achieve an appropriate power level."

ABOVE Torque sensors were successfully introduced in the World Endurance Championship's GT3 division last season

Virtual energy

Not all the benefits of using torque sensors relate directly to monitoring the engine's power output. Integrating power over time gives the vehicle's energy consumption (at least while a positive torque is being applied to the sensors). IMSA, like the WEC, uses this to calculate the consumption of the vehicle's 'virtual fuel tank' using the onboard logger.

"It's still in the driver's hands if they want to extend the stint length with lift and coast. But we no longer see the different engine architectures coming into play, which is something we would see in DPi and previously in GT3, where some engine architectures were better [at extending the stint length through lift and coast] than others," notes Kurdock.

As with the WEC, the virtual fuel tank used in IMSA means that the car's calculated energy allowance can 'run dry' while still retaining ▶

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enough fuel in the physical tank to bring it back to the pits.

The new regulations have also led to changes to the refuelling procedure. Previously, IMSA restricted how quickly the cars could be refuelled. This required a lot of effort from the teams to set the height and capacity of their refuelling rigs to stay within the mandated fuel flow limits. Now, there's no limit on the time taken to physically pump the fuel, but IMSA's scrutineering logger automatically begins counting as soon as it senses that the fuel probe has gone into the car. The hope is that this will simplify the set-up process for the teams and improve parity across the pit stops.

ABOVE The monitoring opens up many possibilities, such as adjusting for ambient conditions, applying penalties or even, in the future, being able to have two different drivers in the same car running to different power levels

RIGHT MagCanica's MTS torque testing rig for development, testing and calibration of racecar MGUK shafts, clutch shafts, secondary shafts, and driveshafts. The electro hydraulically-driven actuator can reach a maximum torque rating of 5,650 Nm

LEFT As in WEC, IMSA now operates a 'virtual fuel tank' that can be monitored in Race Control

Future possibilities

In the future, the ability to monitor power and energy usage could open up even more options. Cost considerations and the significant disparity in vehicle architecture mean that there's no imminent likelihood of GT racing adopting hybrid powertrains, but torque sensors would be a useful tool for the series organisers if this were to happen.

> *"IMSA invites each manufacturer to define its own unique torque curve"*

"The question of when and if hybrid technology might be integrated into that technical formula is very much up to the manufacturers and the FIA," Kurdock points out. "But, for sure, the tools that we've put in place here – like in GTP and Hypercar – permit a variety of powertrain technologies, including hybrid and non-hybrid, two-wheel drive and four-wheel drive to be used and balanced against each other. When and if that happens, the technical regulations that we've put together for 2025 would be able to adapt to it."

The potential applications of power and energy monitoring, based on torque sensor data, could even extend to the sporting regulations. "It's a technology that allows us to regulate power and that's a game-changer," comments Kurdock. "It does get you thinking about the possibilities of how we could use that in-race. Hypothetically, if you wanted to reduce power to apply a penalty or possibly increase it for a particular portion of the race [you could do that]. Two drivers in the same car could have different power levels.

"It's all within the realms of possibility, but whether those are the kind of things that we want to see integrated into endurance racing is a totally different question. Right now, our focus is just on using the technology to create more parity and to better regulate all cars that are competing in GTD and GTD Pro. That's where our focus is."

Fitting torque sensors does involve a cost to the teams (one estimate put that at a not-inconsiderable $60-80,000 per car) but the success of GTP and Hypercar suggests that it's a price worth paying. Following the introduction of torque sensors to the prototype category at Daytona last year, there were three different manufacturers on the podium, separated by less than 15 seconds after 24 hours of racing. Just imagine the fight to the flag that we might see in GTD.

THE YEAR OF THE CAT?

Chris Pickering discovers how Formula E's reigning world champions are adapting to the introduction of the new GEN3 Evo

All photos: Jaguar

THE start of the GEN3 Evo era in Formula E has been something of a rollercoaster for reigning teams' champion Jaguar TCS Racing.

The first round in São Paulo saw Mitch Evans fail to set a time in qualifying after his car came to a stop in the opening minutes of the session – seemingly in a repeat of powertrain issues encountered during practice.

The Kiwi star started from the back of the grid with little hope of a top 10 finish, but after an incident-packed race with two red flags, he stormed through the pack to take the lead. In the end, he scooped victory by less than four tenths of a second, becoming the first driver in Formula E history to win from the back of the grid.

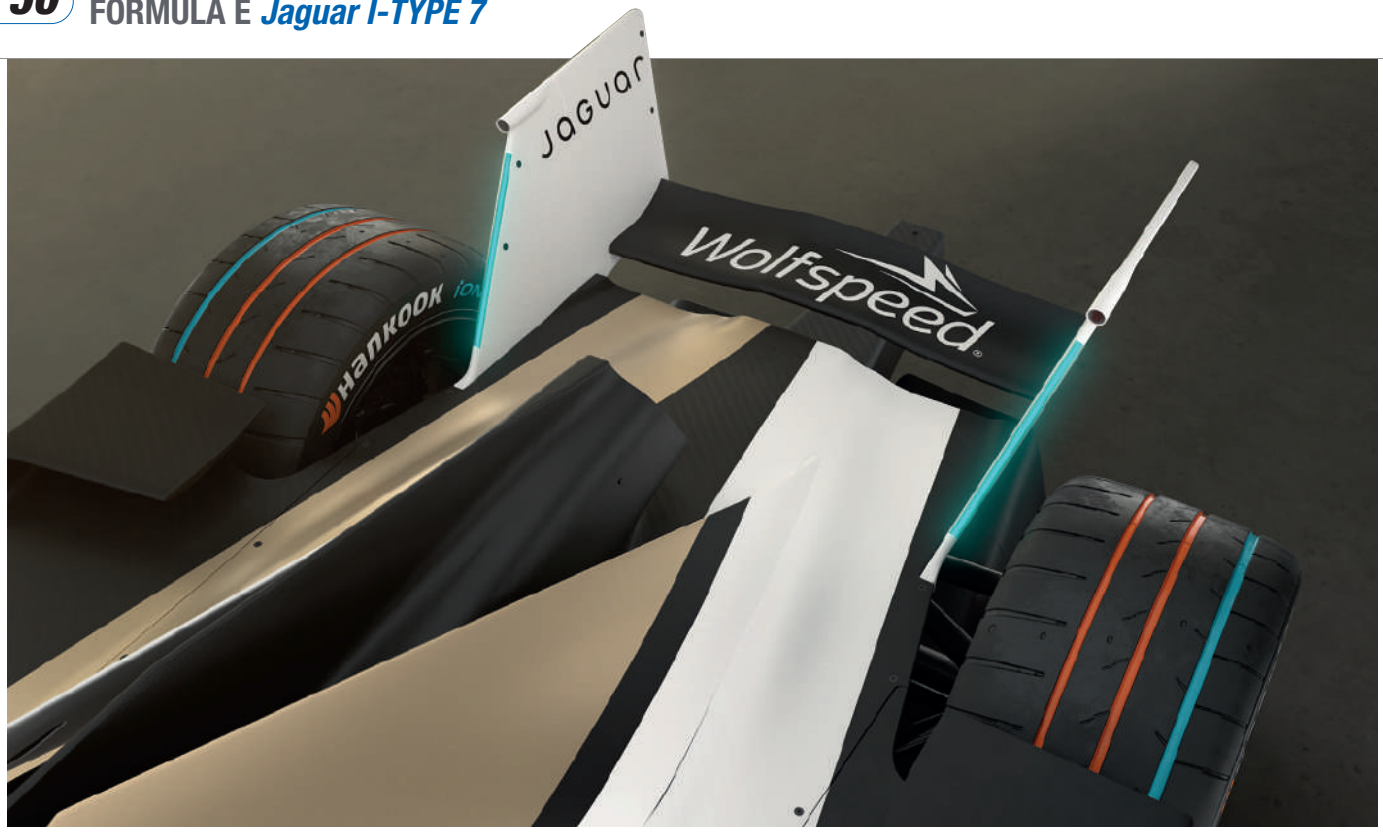
> *"Capable of 0 to 60 mph in 1.82 seconds – 30 per cent faster than a Formula 1 car"*

The second round in Mexico served up further drama. Evans qualified fifth but was forced to retire after he broke his front suspension in a collision on lap 31. Team-mate Nick Cassidy finished in 14th, having started from the back of the grid after being stripped of his qualifying time due to a throttle map infraction.

Highs and lows, then, for the start of Season 11, but the team remains in confident mood. The transition to GEN3 Evo comes after two successful seasons under the Gen3 regulations for Jaguar. Always competitive, the Jaguar powertrain took customer outfit Envision Racing to the Teams' Championship in Season 9, before the works team lifted the trophy in Season 10 (with Evans just six points adrift of the drivers' crown).

"We were very competitive coming out ▶

ABOVE The combination of more grip, all-wheel drive and less drag has made the GEN3 Evo the fastest single-seater racecar on the planet



of Gen3," comments Jaguar TCS Racing's head of vehicle development, Gavin Anderson. "That era had brought a more diverse range of circuits. The introduction of Portland during Gen3 was little bit unexpected and that was probably pretty much on the limit of what everybody's car was designed to cope with. Similarly, Misano, which we went to in Season 10, was a bit more of a traditional race circuit, rather than the street tracks where Formula E had originated. So, we knew we would be pushing more of the boundaries of the car, starting to get into high-speed corners and things, rather than just bumpy, twisty street circuits."

supplier. As before, a single all-weather tyre is used, but a new design provides up to 10 per cent more grip, as well as using a higher percentage of recycled content. In total, some 35 per cent of the tyre is now recycled or sustainable.

"The new tyre is definitely a step up in performance compared to the previous one. And ultimately that means it's a bit softer in terms of its compound to achieve that slightly higher working range," comments Anderson. "So it is more susceptible to things like graining, overheating and wear than we've experienced before in Formula E. We didn't really see that in the first race in São Paulo, but I think during the season there will definitely be times when the team will need to be managing some of those aspects of the tyre."

> *"Pole position in São Paulo was 3.86 seconds faster than Formula E's previous visit to the track"*

Even before the Evo updates, the Gen3 cars were exceeding 170 mph in qualifying at Portland. They're now the fastest accelerating circuit racers on the planet, capable of 0 to 60 mph in 1.82 seconds – 30 per cent faster than a Formula 1 car, and a full second quicker than their Gen2 predecessors. The main reason for this, of course, is the use of the front powertrain to provide all-wheel drive in qualifying duels, race starts, and Attack Mode.

Hankook, which took over from Michelin at the start of Gen3, remains the tyre

More performance

There are a host of other updates in the Evo package. The revised bodywork is designed to be more resistant to impacts, allowing drivers to go wheel-to-wheel with less chance of damage, but it also reduces drag and improves aerodynamic efficiency. All cars come

ABOVE Improved aero will enable cars to run closer than ever before, while new Hankook iON tyres offer 10% more grip and a significant challenge for all teams to understand their characteristics

RIGHT Celebrating the Teams' World Championship success with the Jaguar Land Rover employees

with a redesigned front-wing, new rear winglets and a narrower nose.

There are also changes to the software, including the introduction of traction control on the front powertrain. The end result is a car that's significantly quicker over the course of a lap. Pole position in São Paulo at the start of this season was 3.86 seconds faster than Formula E's previous visit to the track, with the fastest race lap some 3.28 seconds faster than before. At Mexico City the difference was smaller, but still significant, with this season's pole position time 2.31 seconds faster than before and the fastest race lap 2.20 seconds quicker.

Jaguar has worked on optimising the new car, known as the I-TYPE 7, for the longer straights and faster corners that are increasingly found on the new Formula E tracks. But the tighter street circuits like London and Tokyo remain, and this contrast introduces its own complexity, Anderson points out: "Being able to configure the car and the powertrain to go between those different types of circuits, from twisty, bumpy circuits to circuits where grip in high-speed corners and balance is much more important: it's quite a big challenge overall for the team to try and balance those things. And all the time, we're trying to do all the normal racing car things like keeping stiffnesses and masses under control as well."

Energy management continues to be a huge topic in Formula E. Despite the reduced drag of the Evo cars, longer tracks and higher speeds suggest we will continue to see peloton-style racing, where drivers seek to actively avoid being the lead car in the pack during the early stages of the race so they can save energy for a push later on. To a certain extent, São Paulo has already confirmed this, and tracks like Portland are likely to favour the peloton approach.

"Portland [in Gen3] was quite an extreme version of the peloton-style racing," notes Anderson. "You've got a very wide main straight that funnels down. We've seen a couple of times during the races there, where there was perhaps a bit of reluctance for cars to lead into the first corner. There's a bit of an energy cost there, punching a hole in the air for everyone else to follow ... We'd done a lot of testing on the powertrain side [going into 'GEN3 Evo], so we were quite confident that our powertrain was able to deliver competitively at those races and those types of circuits. It's more about the strategy side and how the variables play out." ▶

Pit Boost

One of the big changes for Season 11 will be the arrival of Pit Boost – a mandatory pit stop that will see the cars plugged into a fast charger for 30 seconds, adding around 10 per cent battery charge. Originally known as Attack Charge, the system was first proposed for the start of Gen3 back in 2022 and it was successfully trialled during testing last year.

It's set to be a strategic curveball, and likely to be used at double-header rounds to mux things up between the two races. It will arrive this month for the event at Jeddah.

> *"Attack Mode is now too powerful to ignore: teams will have to embrace it and allow for the additional energy consumption"*

"Pit Boost is looking relatively straightforward from our point of view. You're not allowed to cool the car during the pit stop or anything like that. There's a limitation on the number of crew you can have in the pit lane and they have to be wearing the appropriate safety equipment, so there are pretty clear guidelines in place already," notes Anderson.

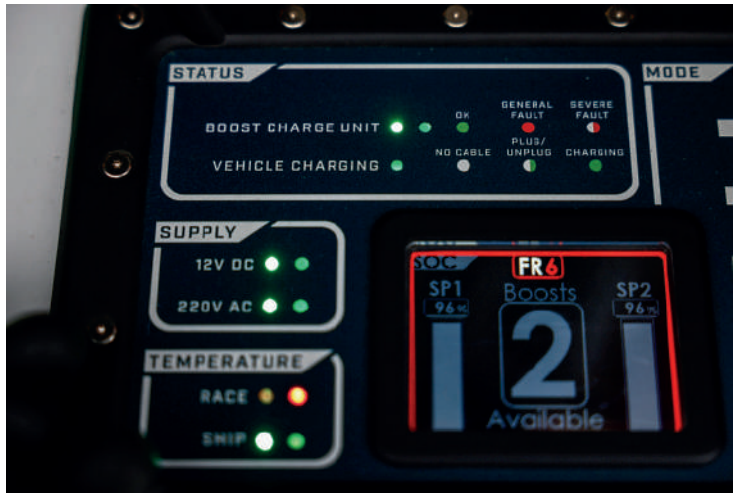
"We've done a good number of practices, but as with any race team we're taking that opportunity to learn and improve our processes. There are competitive advantages to be made there, if you can do that more efficiently than somebody else. There's also the software side to consider. We're putting quite a lot of energy into the battery, so that's going to increase the temperature, which is something we will need to manage."

The teams won't have any access over the control and calibration of the charger. They're also subject to a minimum pit stop time. But the challenge will be getting the pit stops as close to that time as possible – and as consistently as possible.

"A couple of seconds lost in that phase will be difficult to make up on the track," Anderson comments. "It will cost you energy, and you need to make that up on track, which you'll have to pay back at the end of the race." ▶

ABOVE Hardware and software technology proven on-track in Jaguar TCS Racing's I-TYPE 7 GEN3 Evo will transfer to the next generation of Jaguar all-electric road cars

BELOW Battery energy use is pivotal already. A further curveball will be thrown with the introduction of Pit Boost, involving a fast charge for 30 seconds which adds 10 per cent battery charge



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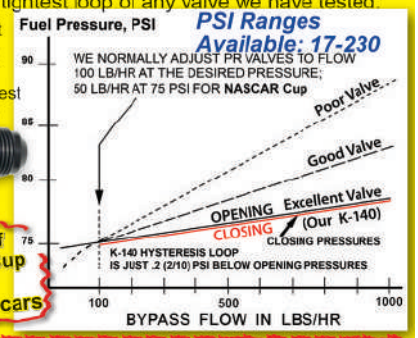

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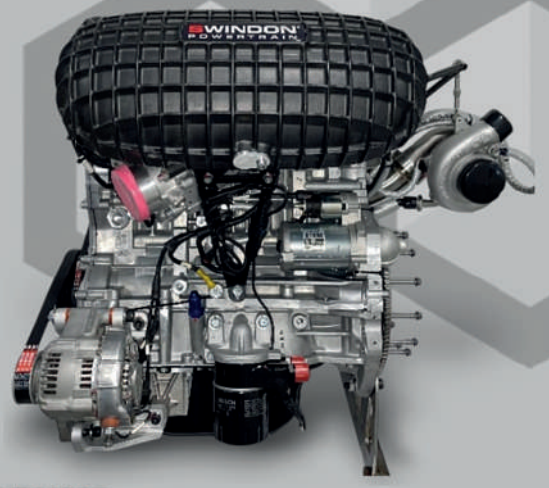

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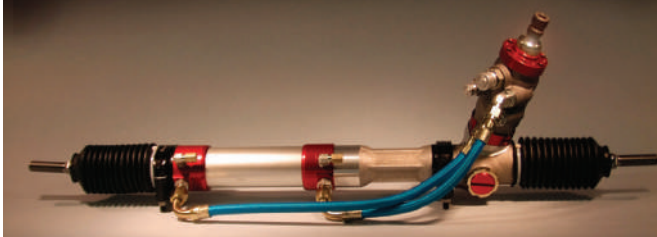

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LEFT Last season's event at Portland, where the Gen3 cars were reaching previously unseen speeds on the straights, saw the birth of Formula E's 'peloton' race phenomenon

BELOW In São Paulo's season-opener Mitch Evans became the first driver in Formula E history to win a race from the back of the grid

Full attack

Attack Mode – where drivers can pick up a temporary power boost, twice per race, by going off-line and driving over a set of coils laid in the asphalt – has taken on renewed significance for Season 11. During Gen3, the benefits of Attack Mode were sometimes marginal. Drivers lose time going off-line and the tyres pick up dust from the less used parts of the circuit, which frequently cancelled out the benefits of the power increase under the previous regulations. But with the addition of all-wheel drive activation, Attack Mode has become a far more potent strategic tool this season. Just how effective was demonstrated in the very first race, where Nick Cassidy punched through the field from 11th position to the lead after becoming the first person to use the revised system.

"Attack Mode is much more back to how it was in Gen2," comments Anderson. "With the four-wheel drive and the traction control, the drivers are really making use of the extra power, which they weren't in Gen3. Now it's a real thing; the cars are quick. You get a good exit out of the corner and you can easily overtake two or three cars on a decent straight, as we saw with Nick. The timing of that is going to be quite critical now, and [its impact] will vary from track to track, but it's going to be pretty powerful at most circuits."

The benefit of a well-executed Attack Mode is now so strong that it has had a fundamental impact on the way that drivers and race engineers approach their strategy. Previously, the benefit in track position had been minimal, so energy management tended to take priority. It was often better to stay where you were and conserve energy. Now, it's too powerful to ignore, which means that teams have to embrace Attack Mode and allow for the additional energy consumption. One of the big questions is how this might be combined with Pit Boost later in the season.

> *"We have a lot of different tools at the drivers' disposal to help them manage the balance of the car"*

Despite the additional energy consumption that's likely to come from using Attack Mode, Anderson says he's not expecting a significant increase in the energy storage allocation given to the teams: "Fundamentally, we expect it to be roughly the same. It might vary a little bit compared to the numbers from last season [in Gen3], but we think they're going to be around the same.

Gaining traction

Formula E has been using the front powertrain for energy recovery since the beginning of the Gen3 era, but it wasn't until the Evo updates arrived at the start of this season that the front motor had been used for traction. Predictably, this has a huge impact any time that the car is traction-limited, and it provides another tool for the engineers to fine tune the car.

"We work very closely with the drivers, so we have a good understanding of the grip levels and how those vary in different parts of the track," comments Anderson. "Working with the driver, how they blend the torque when you're in that four-wheel drive mode between the two axles makes the balance quite different compared to when they're just in rear-wheel drive. And obviously you're just fundamentally trying to maximize the acceleration all the time."

Managing the torque split comes down to a combination of the vehicle setup and the driver. There's no remote telemetry on the car, so the engineers are reliant on radio communications and

post-session feedback from the drivers. Simulation is also heavily employed to configure the various switchable options that the driver has access to in the cockpit.

"It's a very technical sport from the driver's point of view. They need to really understand what they have available on their steering wheel, how to access those settings and which ones are appropriate to tune at which point," comments Anderson. "We have a lot of different tools at the drivers' disposal to help them manage the balance of the car and fine tune it, for instance between low, medium and high-speed corners. We also look at the phases the tyre goes through as well. We think there will be races where that will come into play."

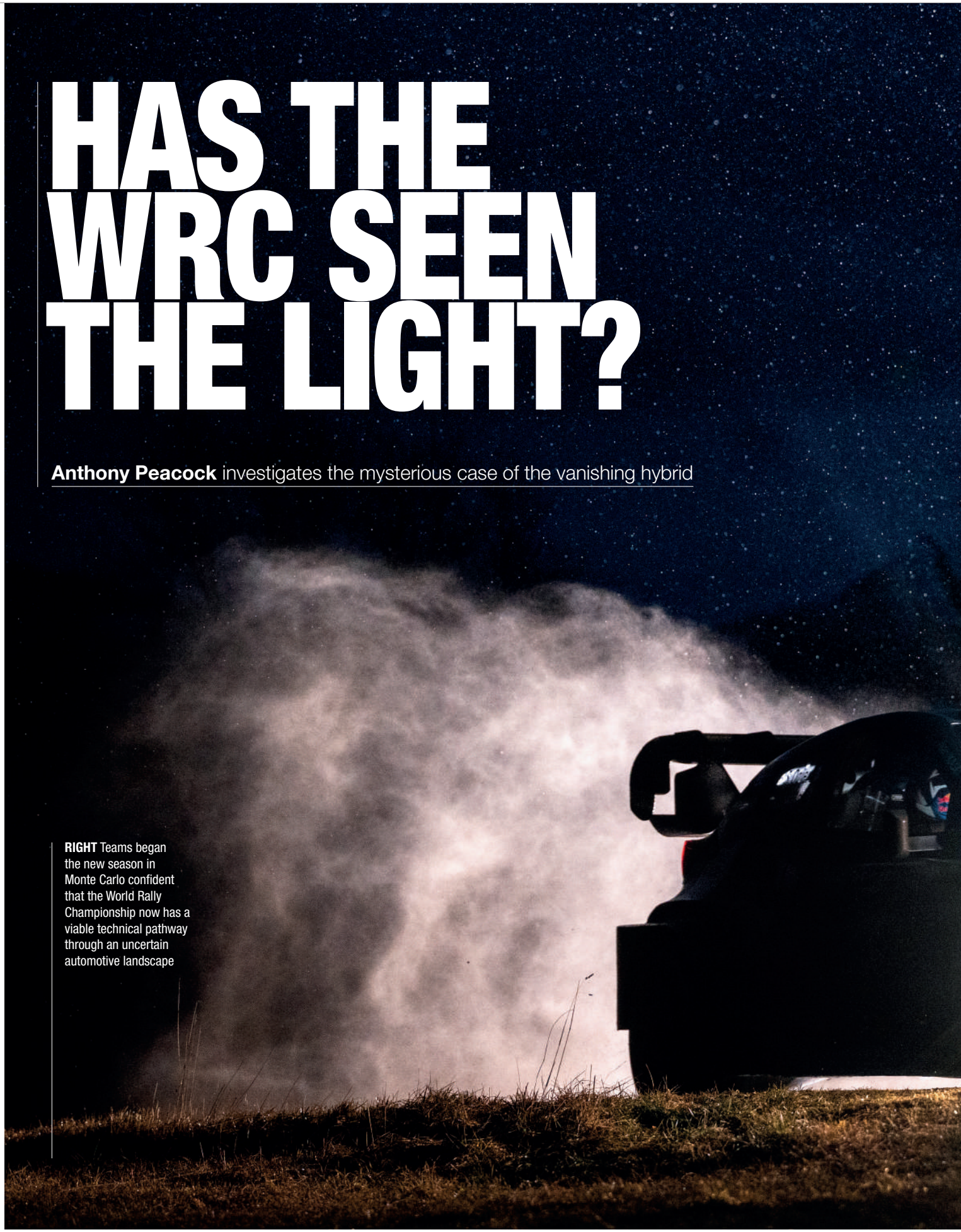
A lot of preparation takes place on the simulator, before the team even reaches the track, he explains: "We do a lot of work with the drivers, making sure they understand what tools they have available to them and what things might work at the next race. Similarly, with the setup, we have some degree of freedom on things like springs and damper settings. We spend a lot of time trying to understand what stiffness we should be running for a given circuit before the event, and then we carry out post-event correlation as well. It's very important to get the drivers back in the simulator afterwards to close that loop and make sure that you learn and improve for the next step."

So, what is the next step for Jaguar? Another teams' title would no doubt be very welcome, but there's also some unfinished business in the drivers' championship. Both Jaguar works drivers were in with a chance of winning the title until the very final round last season. In terms of race wins, Evans is tied with Sébastien Buemi and Lucas di Grassi as the most successful drivers in the history of Formula E. That also makes him the most successful driver never to have won the championship.

Cassidy, meanwhile, scored more visits to the podium than any other driver last year and only had his title challenge compromised by bad luck. If Jaguar can achieve consistency this season there could well be more silverware on the horizon.

HAS THE WRC SEEN THE LIGHT?

Anthony Peacock investigates the mysterious case of the vanishing hybrid



RIGHT Teams began the new season in Monte Carlo confident that the World Rally Championship now has a viable technical pathway through an uncertain automotive landscape

NOW you see it, now you don't – and shortly (in two years' time, to be precise) you'll probably see it again.

We're talking about hybrids in the WRC, which had a fragile and largely unloved three-year cameo appearance from 2022 to 2024, before being quietly shelved for an interim set of evolved regulations that made their debut on Rally Monte-Carlo this year and will run until the end of 2026.

The 'new' regs brought in for this year are in reality just a spit and polish. The 1.6 turbo engine is the same as it was before, with the same P1 fossil-free fuel, but the effect of ripping out the hybrid system is to make the cars lighter by 87 kilograms and 130 horsepower. The power-to-weight ratio has been maintained though by reducing the turbo restrictor from 36 mm to 35 mm. The overall effect, according to most drivers, is to make the cars feel a bit more lively than they were. The stage times were very similar to last year – which was also the objective.

"It's a simpler car; much more like what a rally car should be," said 2019 WRC champion Ott Tanak. "Even though we've lost a bit of power, we've lost a bit of weight too: and weight is everything. If it's lighter, the car is more playful."

Not just that, but it's much safer – as you now take less weight to the scene of an accident – as well as being less complex for rookies, as deleting the hybrid removes the concentration-sapping dilemma of energy management. It's less likely that someone like young Josh McErlean, making his debut in a Rally 1 Ford Puma, could have finished as high as seventh on Rallye Monte-Carlo this year if the hybrid had still been in place.

Big lump

The current car has also given the engineers a bit more scope, as they now have to play with ballast – which means they can place it exactly where they want – to hit the minimum weight limit. Rather than having a big electrical lump weighing close to 100 kilograms in the middle of the car they can now ▶

> *"A sweeping revolution that will be very much more than this year's quick fix"*

Red Bull Content Pool

put the weight where they like, and the cooling configuration is also different – with no holes needed to cool down the batteries.

The only other significant aspect that the teams had to revisit for 2025 was the gear ratios, to compensate for the missing low-down shove previously provided by the hybrid. So all told, it was a reasonably easy fix from 2024 to 2025 that most people approved of. And that was just as well, because the regulations were only signed-off last November, after nearly a year of prevarication, just two months before the start of this year's Monte.

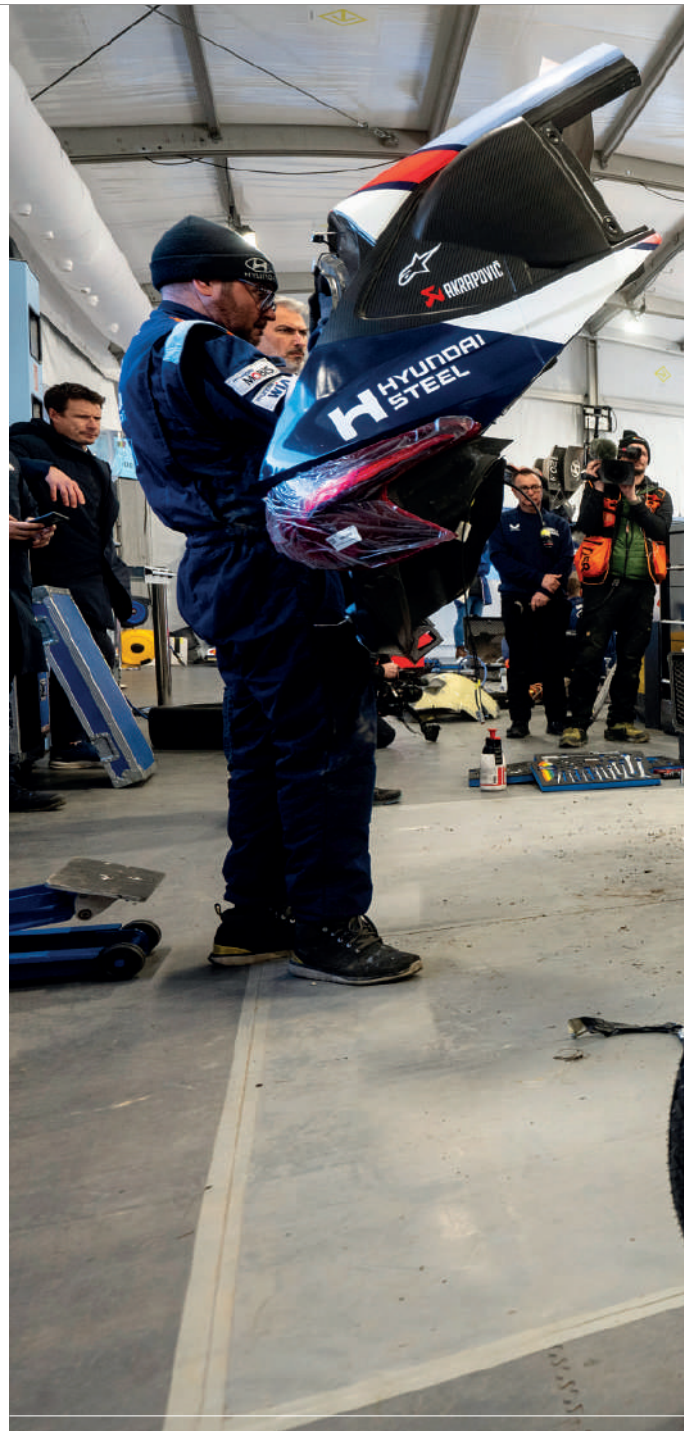
The good news is that the set of technical rules from 2027 was already approved by the FIA's World Motor Sport Council on 11 December last year – less than a month after the 2025 rules were signed off – bringing in a sweeping revolution that will be very much more than this year's quick fix.

But while plenty of criticism has been put at the door of the beleaguered FIA, the uncertainty of the long-term direction of the WRC rulebook is hardly its fault. At the heart of it is a genuine uncertainty over the very future of mobility. Or rather, how it will be fuelled. The truth is, nobody knows with any degree of certainty which sort of propulsion manufacturers will be favouring in five years' time – and what the general direction of engineering travel will be.

As a result, the 2027 technical regulations are extremely open-ended: even by the standards of an FIA rulebook. There are some broad guiding principles; mainly the desire to significantly reduce costs for manufacturers, and open up extra

BELOW The Hyundai group is a fan of electrification but, like its fellow manufacturers, had to concede that the costs of the WRC's spec system threatened the survival of the series

BOTTOM The ability to 'scale' the bodywork opens the WRC to a much wider range of base vehicles, including SUVs and even concept cars



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ABOVE All manufacturers will adopt a standard safety cell as part of WRC27's cost-cutting drive

possibilities for more than the current three to join. There will be much more flexibility around bodywork, for example, which allows for a wider variety of car models as well as bespoke designs (which flings the door back open to 'rally specials' – a bit like the Lancia Stratos back in the day).

Richard Millener, team principal of M-Sport, comments: "It could even open the door for us to make our own car in future – and that applies to other privateer tuners too. If you look at the model of Haas in Formula 1 for example, that provides an interesting template. One thing that's for sure is that you can't rely on OEMs anymore: there are too few of them and they tend to be separated into big groups, who don't want their brands competing against each other. But the corollary is that if you halve the cost, it makes it more appealing to them – so you could end up with a Citroen versus Peugeot scenario again, as well as more private teams in future."

> *"Privateer tuners could build their own car. The Haas model in F1 provides an interesting template"*

After a few choppy years of upheaval, the FIA also wants the 2027 regulations to be the start of a 10-year cycle, in order to provide a stable platform to grow the sport.

Rules, by definition, are meant to be prescriptive ▶

Red Bull Content Pool

– but the FIA is making a virtue of how flexible the 2027 regulations are going to be. Which means that rally cars as we know them – based on production bodyshells – will be no longer. Instead there will be a common safety cell onto which production-based panels can be bolted: more like NASCAR.

This means that we could get hatchbacks competing against SUVs (the fastest-selling type of car on the European market) against coupés – so we will certainly see a lot more variety on the championship in years to come. It's also going to be much easier for manufacturers to switch from one model to another.

As for cutting costs; it's more a question of them being slashed by around 50%. Costs in 2027 will be capped at €345k for a basic car and €385k including the gravel and asphalt rally kits, ready to compete.

Rally 2 ballpark

This isn't actually an insurmountable gap compared to the cost of a current Rally 2 car, which is in the region of €300,000. And it's not just the cost of the cars themselves that are coming down, but also running costs thanks to further limits on the number of personnel at each rally (currently a top team brings around 75 people to each event). This will be achieved by enhancing the data connectivity in the service park so that more engineers can work off-site, and by making use of local infrastructure – which will essentially mean that teams will have to bring less stuff (such as motorhomes) and therefore fewer people to build and manage them.

There will also be some streamlining of logistics, which is designed to drive down running costs further and create more of a level playing field between teams like M-Sport and its full manufacturer rivals.

If this sounds unclear, it's because this is how the regulations are written. And these new rules, as Millener gratefully ▶

ABOVE There is potential for cross-over between the WRC and World Rallycross Championship (pictured). A manufacturer could run concurrent programmes with the same car, potentially with a different powertrain

BELOW Hayden Paddon's Hyundai Kona EV is one of the few non-ICE rally cars to have competed in recent years, but the regulations do leave the door open to incorporate fully electric technologies

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acknowledges, were written in full partnership with all the sport's stakeholders. So there is a genuine spirit of harmony and collaboration.

But where it gets interesting is what will power these future cars. Basically, anything goes: for now at least. The 2027 regulations are designed to accommodate internal combustion engines, as well as hybrid systems and fully electric powerplants. It's expected that internal combustion engines, with or without hybrids, will lead the way – and then, nobody really knows...

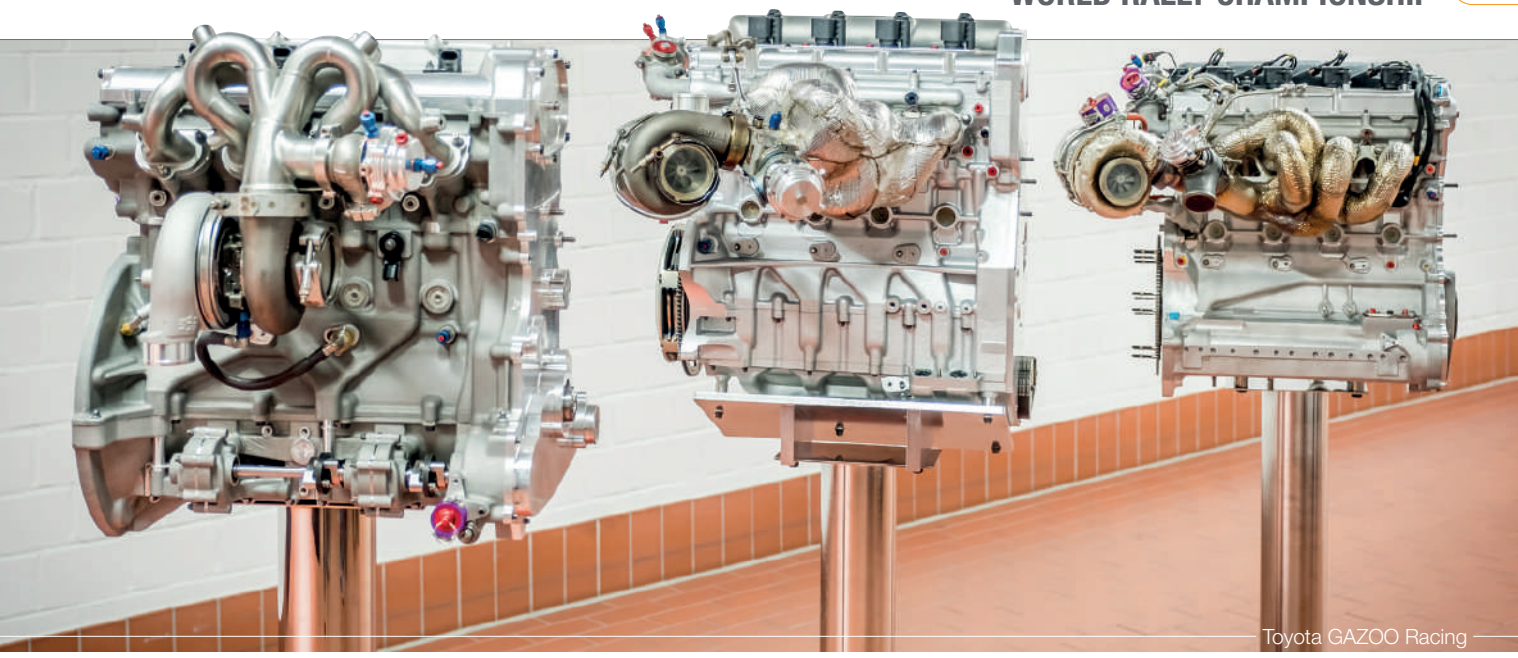
The obvious difficulty will be finding some form of GT-style balance of performance to keep everything on a level playing field. And for that, the FIA has planned a 'torquemeter' to "limit engine development and synchronise performance between the different powertrain options as they develop."

This system was already successfully used on the Dakar this year, and it means in future powertrains as diverse as hydrogen and electric could compete equally against each other – if, of course, the local infrastructure exists to support that, under the current WRC format. And that is a whole other discussion for a different day.

Working together

FIA President Mohammed Ben Sulayem elaborated: "These regulations are critical to the long-term growth. In 2023, we identified that there was the need for the rally stakeholders to come together and begin a more coordinated way of working. That we have published these regulations for 2027 highlights

RIGHT The lineage of the WRC's turbocharged 1.6-litre engines continues, but with an eye on future propulsion systems


Toyota GAZOO Racing

Newspress

LEFT Opening the door to bespoke designs could free teams to produce their own 'Stratos'

> *"Nobody knows with any degree of certainty which sort of propulsion manufacturers will be favouring in five years' time"*

how our work has been a success."

As WRC Commission president Pernilla Solberg (the wife of Petter and mother of Oliver) put it: "We set some clear objectives based on what the competitors, organisers and fans were telling us, and this has resulted in a set of regulations that will massively reduce costs while giving the WRC the flexibility to remain relevant regardless of the shifting automotive landscape. We still have some work to do, but I'm really excited for this future."

That work, according to Millener, still needs to include a way of curbing the ever-increasing speed of the current cars and specifying exactly how these disparate power outputs are going to be measured and managed.

Nonetheless, the swift action taken in terminating the lifespan of the hybrid-era cars – which were originally meant to stay in place until the next rules cycle – has bought enough breathing space to ensure that there's a genuinely sustainable set of future regulations in place for the sport to expand like never before. "The only issue," points out Millener, "is that 2027 is basically tomorrow."

When people say the future is now, they're not joking. RT

P1 Fuels

RIGHT Sustainable fuel remains a key tenet of the rules framework

THE RAPTOR CLOSES IN ON ITS PREY

M-Sport spearheaded Ford's assault on the Dakar Rally with its new Raptor T1+, which was rewarded with a podium finish. **Hal Ridge** reports

IT'S January 2024 and British firm M-Sport, with works support from long-term partner Ford Performance, is deep in the Saudi Arabian desert contesting the Dakar Rally for the very first time. At the wheel of a pair of partly-inherited Ford Rangers, former Dakar winner Nani Roma and team-mate Garth Woolridge are battling their way through the gruelling event. After a number of issues, both finish outside the top 40.

But, over 4000 miles away in the Cumbrian countryside, in the north west of England, a brand-new Ford Raptor is already coming to life on the drawing boards of M-Sport's World Rally Championship-winning design offices.

The 2024 event was billed by Ford Performance as a finish and learn effort. While it was public knowledge that the M-Sport-run effort would return with a new car in 2025, what hadn't been revealed was quite how far down the road to putting that in place the outfit was.

In fact, by the 2024 Dakar, the new Raptor had been in the design process for over three months. Only a couple of months later, it would begin testing.

Twelve months on, the fruits of that labour resulted in a podium finish for Swede Mattias Ekstrom on the Raptor's Dakar debut. That run included a brace of stage wins in an extremely strong performance, that could also have offered so much more.

A double DTM champion and World Rallycross title-winner before switching his driving efforts to Rally-Raid, Ekstrom's move to Ford for 2025 gave note of the squad's intentions. His acquisition followed the signing of fellow former Audi team-mate, four-time Dakar winner Carlos Sainz, the pair contesting the event as part of a four-car Blue Oval contingent.

While both headline drivers brought a wealth of experience, M-Sport engineer Jon

> *"The team had a range of objectives, not least to try to break the car"*

Sprackling says that by the time the star drivers had arrived, the relative Rally-Raid rookies [M-Sport] were already satisfied with the fundamental concept of the all-new Raptor.

"When Carlos and Mattias first joined the team, we ran them through the design and I think we were quite pleased really that the concept we'd come up with seemed like it was very good and the feedback throughout testing from the drivers was very positive," says Sprackling. "I don't think we had any major worries that the drivers thought, 'Oh no, this thing is rubbish'. We never had that.

"Nani [Roma] came with a vast amount of experience in rally-raid, so he was pivotal to getting the car to where it was when Mattias and Carlos joined the programme. And then ▶

ABOVE The car's Dakar debut delivered a podium finish and two Raptors in the top five

Short rally, lengthy arguments

Should rally legends have been allowed to continue after early drama? By **Hal Ridge**

MUCH controversy surrounded the retirement of Ford's four-time Dakar winner Carlos Sainz and Dacia's nine-time World Rally Champion Sebastien Loeb in the early stages of the 2025 Dakar event. Both suffered a similar fate.

Sainz rolled his Ford Raptor on the second test, although was able to continue, in part thanks to team-mate Mitchell Guthrie, who stopped to help right the stricken car.

Loeb also made it to the finish of the fourth stage, thanks to assistance from team-mate Cristina Gutierrez, having rolled his Prodrive-developed Dacia Sandrider.

However, both rally legends were forced out by FIA regulations surrounding damage to the roll cage. Neither driver was pleased, Loeb especially discontent in the media.

"It's the same for everybody. We had damage to our safety cell; if we had damaged different members of the chassis, then we could have repaired them," explains M-Sport engineer Jon Sprackling. "But with the safety cell, the only way you can repair it according to the FIA regulations is to completely replace the tubes that are damaged, and we didn't have the ability to do that on-site. When we get the car back, we will decide if we replace those tubes or if it's more cost-effective to just build a new chassis."

However, when asked if the damage sustained and the resulting retirement made cause for a rethink on the Raptor's design, Sprackling suggested that the British firm could in fact have safely repaired the car, had it been allowed to.

"It's very difficult because you don't want to design your car to be able to shrug off a crash, because if you design a car that can shrug off a crash you're just going to make something that's very, very heavy," he says. "I think it's probably more to do with a regulation thing. We know we could have made repairs to the chassis that would have made it perfectly safe – I did some analysis to show that with changes we could make, the safety wouldn't be compromised in any way, but unless the regulations change, that's kind of where we are.

"But it's the same for everybody. The chassis that we've designed complies with all the stress analysis regulations that we have to with a homologated safety cell and we wouldn't go trying to make it thicker or heavier because it's a lot of weight high up that you don't really want. Carlos would probably have been in the fight [to win, despite the crash] still because it was relatively early on and he managed to get the car back on its wheels and he didn't lose a huge amount of time. It's frustrating but I don't think it necessarily means a design change."

Carlos brought a similar level of experience, and Mattias brought a lot of assistance in setup and dialling in the suspension and diffs. They're all very talented in different ways and they've all worked together very well to the point where we've ended up with a car where we're able to get a setup that suits them all."

Roma's early running was at M-Sport's on-site tarmac test track and in the nearby Greystoke forest, where artificial jumps were created to put the vehicle through its paces. The squad then moved on to Zaragoza in Spain and the renowned Fontjoncouse facility in France with a range of objectives, not least to try to break the car – a brutal endeavour deemed necessary as part of the preparation for taking on the Dakar.

Evolution, not revolution

But, while the team did endure niggles in testing – including transmission problems in Greystoke, a cracked chassis at Fontjoncouse and a broken air conditioning system on Sainz's car while competing on Rallye du Maroc – in the over 15,000 kilometres of running ahead of the Dakar start this year, the focus was on refinement and adaption. Evolution, not revolution.

The team had endured a tough period testing the car's predecessor, the Ranger. That car had originally been created by South African squad Neil Woolridge Motorsport as a T1-specification machine, before being adapted to run to T1+ rules – most significantly meaning a change to a larger wheel size and increased suspension travel. M-Sport faced a relatively easier time with the development of the Raptor, something Sprackling at least in part attributes to the

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Ford Performance

ABOVE Relax, the Raptor didn't swallow M-Sport's mechanics, though the early tribulations did eat up their time

car being conceived for T1+ from the outset.

"Without trying to be derogatory to that car [Ranger], there were suspension limitations. This car [Raptor] was designed to T1+ regulations from day one; we've always designed it to the 350 mm travel and we spent a lot of time getting the suspension right, getting the kinematics correct, choosing our damper supplier and the lots and lots of development work that's gone into that," he explains.

"The chassis has been designed from the ground up using the architecture that we know and the learning that we had from Rally1 [the top-flight World Rally Championship regulations, in which M-Sport runs the Ford Puma] and the limitations of the chassis of the Ranger. We did torsional stiffness calculations, stress analysis serviceability studies, those sorts of things [to refine the chassis]."

The Raptor's T1+ tubular spaceframe chassis weighs in at 2,010 kgs, having undergone what Ford describes as "thousands of hours of design and Finite Element Analysis (FEA)". A focus on the COG [centre of gravity] has minimised body roll in this latest creation, which still boasts 400 mm of ground clearance.

> *"This is very much a Dakar warrior compared to its 'beefy' pickup older brother"*

A different engine configuration for the Raptor was committed to early in the design process. With the mid-mounted, twin-turbo 3.5-Litre EcoBoost V6 unit from the Ranger shelved, the Raptor adopted a naturally aspirated 5.0-litre Coyote Darkhorse, 32-valve V8 engine similar to that used in Ford's Mustang GT3. With a 93 mm bore and 92.7 mm stroke, it delivers 360 bhp. It is controlled by a Bosch electronic engine management system, with air ▶

RIGHT Sadev's SP08 differential has become a go-to product for many of the top teams

LEFT Carlos Sainz struggles on with heavy damage on stage two. M-Sport believed the car could have been repaired and fought for victory

drawn into the inlet manifolds via BMC air filters.

The regulations do not allow much development of standard engine internals. Instead, the freedom lies mainly in the inlet and exhaust manifolds, something M-Sport says it produced "millions" of simulations for while developing the power unit on its in-house dyno.

Sprackling is guarded as to the reasons behind the switch of engines, although he does acknowledge that in a gruelling event like the 14-day, 12-stage Dakar marathon, sometimes simplicity, in terms of having less components around the engine configuration, like turbochargers and intercoolers, can have its reliability benefits.

"Engine choice-wise, we chose quite early on. The regulations have evolved a little bit since then (with cars running a torque meter), but with the regulations that we had in front of us at the time, we decided that the V8 was the best of our options," he explains.

> *"In such a marathon, sometimes simplicity, in terms of having less components, can have its reliability benefits"*

"We believe it's the best choice. There is definitely a reliability element to it. On paper you'd say there are fewer elements that can go wrong. You don't have to package turbos, but you do have to package quite elaborate exhaust manifolds – it's swings and roundabouts really, it's not clear-cut, that's for sure."

The engine continues to be mated to Sadev's T1+ transmission, popular among Rally-Raid front-runners. A longitudinally-mounted six-speed sequential gearbox is coupled with a limited-slip ▶

Ford Performance

ABOVE Centre of Gravity was an important focus throughout the design and packaging process

BELOW Podium celebrations, but the team left the event knowing that more was possible

Ford Performance

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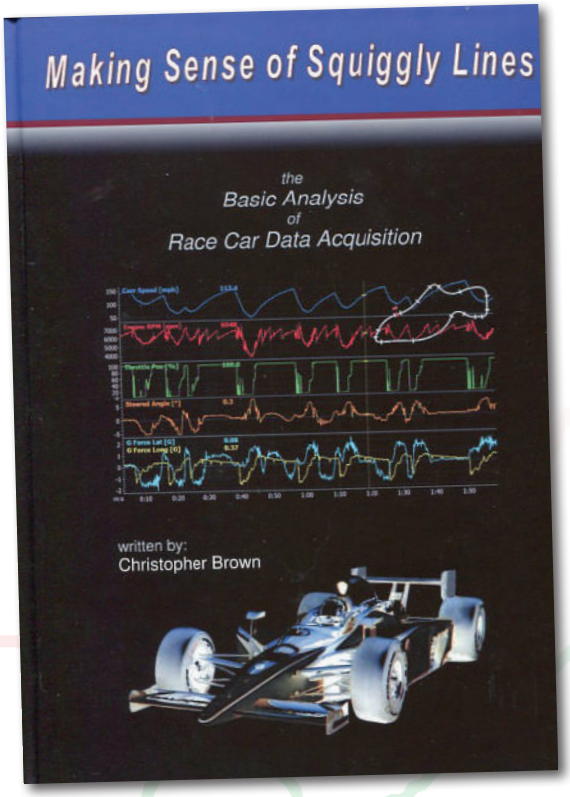

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> *"Feedback throughout testing was very positive. We had no major worries that the drivers thought, 'Oh no, this thing is rubbish'"*

centre differential, fully adjustable with ramps, friction faces, and preloads to suit the various driver preferences and conditions.

2025 brought the introduction of French firm Sadev's new SP08 Differential, used in the front, rear and centre of the Raptor. The design of the SP08 has been optimised for space, reducing weight and further improving reliability and performance. It has found favour in a range of machines, like Dacia's Sandrider (developed by Prodrive) alongside the Raptor.

Damper decision

As part of the four-wheel-drive Dakar system, hydraulically-operated locks can be utilised at the push of a button from inside the cockpit to help crews through the most challenging terrain.

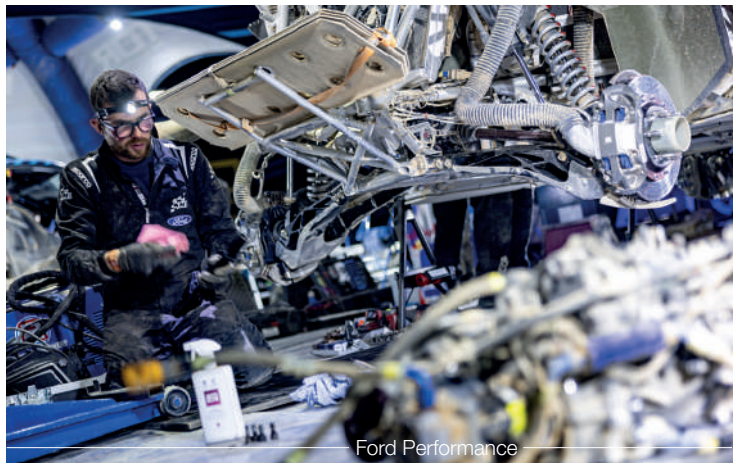
The Raptor differs in several other areas to its predecessor, including the damper supplier. The car was developed with the ability to accommodate different suppliers' products, allowing the squad to do evaluation testing and choose what worked best on a 2.3-metre wide, 3-metre long wheelbase machine with a 50 kg wheel and 37" BF Goodrich tyre at each corner.

"We didn't make that [damper] decision until a little way into testing," notes Sprackling. "In the end it was between Reiger and Fox. We gave them equal opportunity basically and we felt that the Fox had the bigger potential to get us where we wanted and we've since worked very closely with them for the rest of the year to develop what we think is a good product."

Retaining a double-wishbone suspension concept ▶

ABOVE A switch to Fox dampers enabled M-Sport to benefit from the US company's extensive Rally-Raid experience

BELOW The M-Sport team might have WRC and Rallycross titles to its name, but it is still on a steep learning curve when it comes to the Dakar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LEFT The original Ranger's engine was replaced with a Coyote-based 5.0-litre V8 taken from the Mustang family

BELOW Extensive testing, here in Morocco, tried to emulate the conditions the team would face in Saudi Arabia

from the Ranger, the Raptor utilises eight five-way adjustable Fox dampers (four coilovers and four external bypass) and, coupled with Eibach springs at each corner, each is fitted with an adjustable crossover collar to provide progressive stiffness and prevent bottoming out. Adjustment comes thanks to high- and low-speed compression damping, while internal hydraulic bump-stops control end-of-travel movement. The position-sensitive external bypass dampers are designed to absorb the biggest impacts, while damping rate increases throughout the suspension travel curve.

Good partnership

The braking package was also changed from Ranger to Raptor. The latest creation is fitted with Alcon's 6-piston monobloc calipers, utilising 355 mm vented discs and Endless pads, each corner benefiting from cooling fans in an effort to control brake temperature.

"There wasn't anything wrong necessarily with the Brembos we had on the old car, but we had discussions with Alcon and it seemed like we had a good partnership there so we decided to go with them," says Sprackling.

Arguably though, where the Raptor is most different to the uninitiated, over its predecessor, is in the aesthetics of the composite bodywork that clads the spaceframe. While the latest creation is very much a Dakar warrior compared to its 'beefy' pickup older brother, the looks are far more than just cosmetic.

One key benefit for M-Sport with its OEM-link with Ford is with the processes at its disposal. The Raptor has been through "thousands of hours in computational fluid dynamics (CFD) and wind tunnel testing" to achieve the FIA-regulated top speed as quickly as possible, while also offering the crew the best visibility

possible. The car features extra strength in some areas, sacrificial panels in others, such is the nature of taking on such a range of terrains across the event.

Ford's chances of claiming victory on its first major Dakar effort with M-Sport were dealt a major blow early on when Sainz rolled out of the event on the second stage. He did make it to the end of the test but roll cage damage forced him to retire (see sidebar).

Team-mate Roma went on to claim the car's first stage win on the tenth test in a fightback drive, before Ekstrom, having been second in the event's Prologue, ran up front for the duration. He set the fastest time on the 11th stage and netted his first Dakar podium in third. It was a strong result for the Swede and for the Blue Oval, but amid the joy, all parties surely left the Middle East wanting more?

> *"It's swings and roundabouts: you don't have to package turbos, but you do have to package quite elaborate exhaust manifolds"*

If the squad can return in 2026 having made a similar gain in performance to its efforts over the past year, the other major players will need to also up their game.

"We know the areas where we're strong and the areas we have room for improvement, but I think it [the Raptor] is pretty much exactly where we expected it to be relative to the competition," concludes Sprackling. "As a team we have the experience of doing the event last year but in terms of how we compare to Dacia, X-Raid and Toyota, they've got a lot more experience than we do as a team.

"We've brought in more people with a lot of experience, but we've grown to four cars here and some people are new to it. It's a challenge to share that experience across everyone and do the best we can. We're already in the design process of doing an evolution of the car; there's a very, very long list of things we want to change but there's nothing we think we've done fundamentally wrong, we just think we need to try and refine it. It's not revolution, its evolution." RT

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BLUE PLANET MEETS DAKAR

THE SEQUEL

Extreme H is opening up the supply of its hydrogen fuel cells to entice OEMs to the party. It's a dangerous game, reflects **Sergio Rinland**

WHEN Extreme E was launched in 2019, we wrote a column praising the idea, suggesting it was 'Blue Planet meets Dakar' and we still think so.

But, after three complete seasons and a truncated 2024 campaign, Extreme E is leaving the gate open for Extreme H, a similar concept but using a Hydrogen Fuel Cell (HFC) as a range extender; so no relying on the battery capacity anymore, it relies on the fuel cell and its hydrogen tank capacity.

The concept is similar to the now-defunct Extreme E. The 10 cars unveiled in January were all built by Spark Racing Technology in France, with batteries supplied by Fortescue Zero (previously Williams Advanced Engineering), and electric motors from Helix. The most important aspect, the fuel cell, was developed and supplied by French company Symbio, a Michelin subsidiary and partner of the Stellantis group for the development of HFCs.

So far, the concept is similar to Extreme E: a common car and powertrain with some styling freedom to add potential OEMs' design cues for their respective SUVs. Great for promoting HFCs and the OEMs' engineers will certainly benefit from the steep learning curve of motorsport to add to the years developing the technology.

HFC is nothing new. It is nearly 200 years-old, invented by Sir William Grove in 1838. The first modern fuel cell was developed in 1932 by Thomas Francis Bacon. The Bacon Fuel Cells have been used in high technology propulsion and mainly by NASA in its spacecrafts since the early 1960s.

In Automotive, it has been an on-and-off affair: under development since GM's 1966 Electrovan and, more recently, the Honda Clarity of 2008. The Toyota Mirai, in production since 2014, was for many years the most sought-after HFC car, with more than 27,000 sold so far. That success was probably a factor in Hyundai's decision to commit a reputed development budget of US$16.7bn to its Nexo, a decision rewarded by 40,000 sales worldwide.

Other OEMs such as BMW, Daimler Benz, Renault, Land Rover and GM are developing HFC cars but still not in full production.

Trucks and public bus developments are more advanced than passenger cars due to the inherent characteristics of such a powertrain being better suited to big, heavy vehicles.

Someone once said, "Hydrogen is the fuel of the future and it has been for many years". In a recent article in the *Financial Times*, columnist Jane Young warmed to that theme, acknowledging: "Hydrogen is yet to become the fuel of the future, but its potential is far from exhausted."

So, welcome Extreme H! But (a small but), last month Extreme H technical director Mark Grain revealed that while the standard HFC from Symbio is generating the energy for the current cars that will start racing at the end of 2025, Extreme H is opening the rules. OEMs who want to participate will be able to develop and race with their own 'off-the-shelf' (if such thing exists!) fuel cells.

This latest turn of events opened a debate: is there a danger it could spark the kind of 'arms race' that Formula E, the sister series, has tried so hard to avoid by using a common battery? Or will this be a huge positive for the industry, allowing OEMs to test and market their offerings?

Given that we have just said above that Hyundai's development budget for HFC is US$16.7bn, I would be inclined to suggest the answer was 'yes' to the first assumption, in spite of regulations that will limit the power and energy of HFCs.

Even though the HFC would not be a primary performance differentiator (batteries and motors will), I would be surprised if OEMs don't start spending zillions to develop products that could help them win in motorsport, in order to satisfy the demands of their marketing departments. A Pandora's Box has just been opened! RT

BELOW Extreme H could become a battleground for OEMs promoting hydrogen fuel cells

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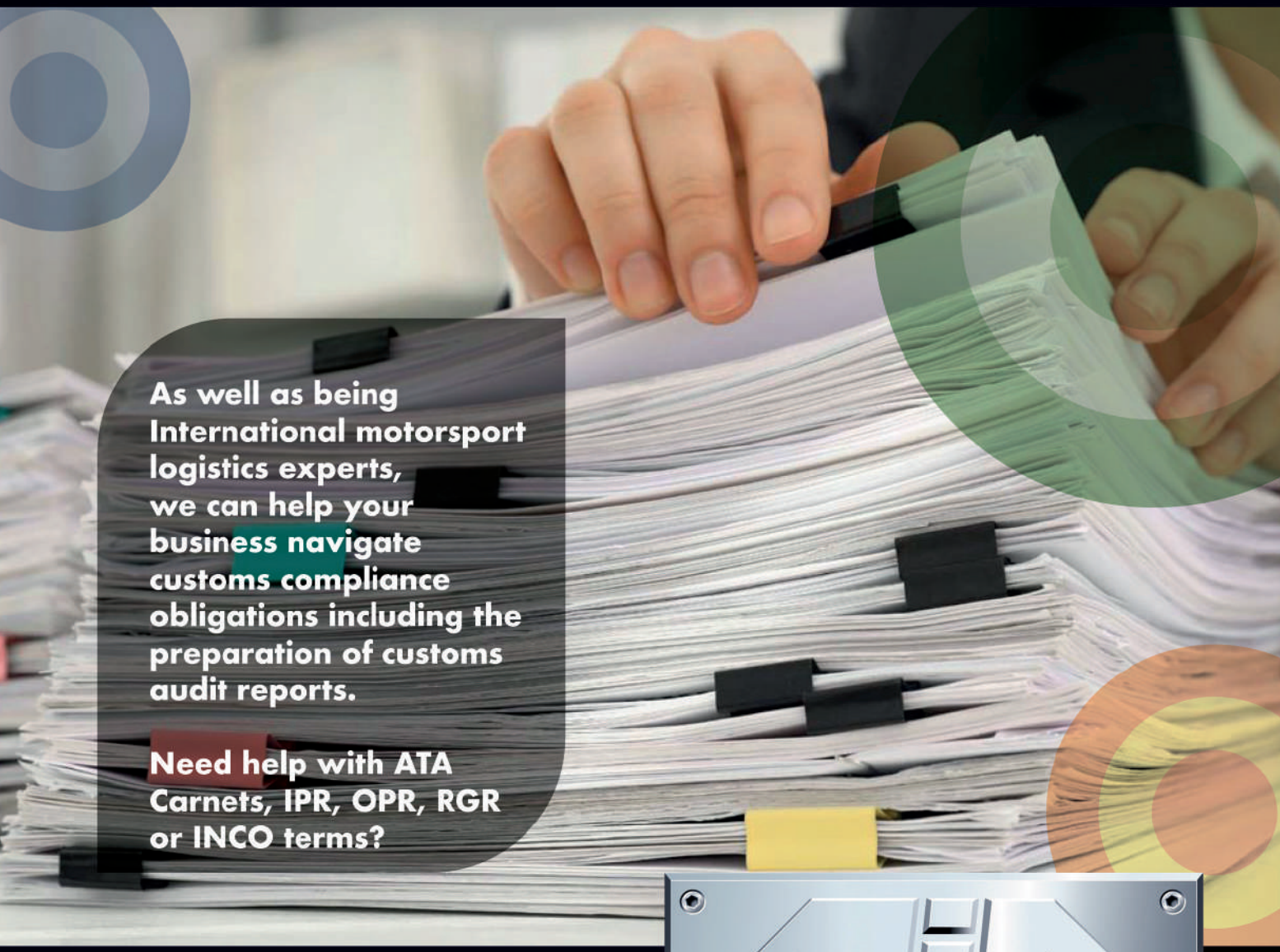

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